THE UNIVERSITY OF ALBERTA

STABLE POPULATION ANALYSIS: MOROCCO

by

(C) RODERIC P. BEAUJOT

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF ARTS

DEPARTMENT OF SOCIOLOGY

EDMONTON, ALBERTA

SPRING, 1972

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "Stable Population Analysis: Morocco," submitted by Roderic P. Beaujot in partial fulfillment of the requirements for the degree of Master of Arts.

ABSTRACT

This study is an application to the Moroccan population of stable population methods to estimate basic demographic parameters from incomplete data.

A stable population is a population that is closed to migration and that has constant age-specific schedules of fertility and mortality. The theory holds that when these three conditions are applied over a long period of time the population will become independent of its initial age distribution so that the growth rate and the proportionate age distribution will also become constant. The quasi-stable variant of this theory shows that the mortality condition can be relaxed without greatly affecting the constancy of the resulting age structure. A series of types (based on analytical and empirical generalizations) has been devised whereby knowledge of the structure of the age distribution and of the rate of growth, among other possible pairs of parameters, is largely sufficient to identify the appropriate model stable population whose characteristics can then be imputed to the given population.

The methodology of stable population analysis and of census survival techniques for arriving at similar estimates are discussed. Establishing the rate of natural growth and the structure of the age distribution can be problematic. The inter-census growth must be adjusted for migration and for differential under-enumeration among censuses. The age distribution can be distorted by two types of errors which are often difficult to disentangle: misreporting of ages, and age- and

sex-selective under-enumeration. The use of ogives (proportions to given ages) as the basis of estimates can largely control for the former type of error. It is proposed that a detailed study of the age-specific sex ratios, of the age ratios, of the census survival rates and of the single-year age distribution can be instrumental both in identifying selective under-reporting and in separating the two types of distortions.

Moroccan census data gathered during the 1950-1960 decade are used. These were found to contain considerable irregularities so that the adjustments described above were an essential prerequisite to the stable population analysis. Considerations of the internal consistency of the 1960 age distribution gave evidence that, after slight adjustments, the proportion at ages (0-9)/25+ could be used as an accurate measure of the age structure.

A series of estimates was derived in order to test the implications of various assumption. Those retained for Morocco Muslems (95% of the total population) in 1960 are as follows:

	MALES	FEMALES
Growth rate (%/yr.)	2.4 - 2.8	2.4 - 2.8
Birth rate/1,000	45 - 50	44 - 48
Death rate/1,000	17 - 26	16 - 24
Percentage under-enumeration	11.1 - 11.3	12.6 - 12.8

Though the remaining uncertainty, especially in the death rate, is regrettable, the inaccuracy of the data did not warrant a reduction in the range of these estimates.

ABSTRAIT

(version française)

Cette étude est une application à la population du Maroc des méthodes de population stable pour estimer des paramètres démographiques fondamentaux à partir de données incomplètes.

Une population stable doit être fermée à toute migration et avoir des cédules constantes de fécondité et de mortalité par âge. La théorie tient que dans le cas où ces trois conditions s'appliquent sur une longue période, la population deviendra indépendante de sa distribution d'âge initiale de sorte que le taux d'accroissement et la distribution proportionnelle des âges deviendront également constants. La variante quasi-stable de cette théorie indique que la condition de mortalité stable peut être soulevée sans grandement affecter la stabilité de la structure d'âge. On a conçu une série de types (fondés sur des généralisations analytiques et empiriques) de sorte que la connaissance de la distribution d'âge et du taux d'accroissement, parmi d'autre paires de paramètres possibles, est grandement suffisante pour identifier le modèle approprié de population stable. Les caractéristiques de ce modèle peuvent par la suite être imputées à la population donnée.

On discute la méthodologie d'une analyse par population stable et également les techniques de survie au recensement par lesquelles on peut arriver à des estimations semblables. Déterminer l'accroissement naturel et la structure de la distribution d'âge peut être problématique. L'accroissement entre recensements doit être ajusté pour la migration et

pour la sous-énumération différentielle entre recensements. Deux types d'erreur difficiles à démêler peuvent déformer la distribution d'âge: fausses déclarations d'âge et sous-énumération spécifique à certains groupes d'âge et de sexe. En fondant les estimations sur des ogives (proportions jusqu'à un certain âge) on peut contrôler pour le premier type d'erreur. Une étude détaillée des rapports de masculinité par âge, des rapports d'âge, des taux de survie au recensement, et de la distribution par âges uniques est proposée pour découvrir la sous-énumération sélective et pour séparer les deux types d'erreur.

Les données sont celles des recensements Marocains durant la décade 1950-1960. Des irrégularités considérables se présentent dans ces données de sorte que les ajustements décrits ci-haut furent une condition prealable essentielle à l'analyse par population stable. L'examination de la consistance interne de la distribution d'âge suggère qu'après certains ajustements légers la proportion aux âges (0-9)/25+ est une mesure relativement fidèle de la structure d'âge.

Plusieurs estimations sont tirées afin de tester les conséquences de diverses hypothèses. Les résultats retenus pour les Marocains Musulmans (95% de la population totale) en 1960 sont:

	HOMMES	FEMALES
Taux d'accroissement (% par annee)	2.4 - 2.8	2.4 - 2.8
Taux de natalité par mille	45 - 50	44 - 48
Taux de mortalité par mille	17 - 26	16 - 24
Pourcentage de sous-énumération	11.1 - 11.3	12.6 - 12.8

Quoique l'incertitude, surtout de taux de mortalité, demeure regrettable, l'inexactitude des données ne justifie pas une réduction de l'écart de ces estimations.

ACKNOWLEDGMENTS ARE DUE

To Dr. Karol Krotki who chaired my committee, stimulated my interests, and arranged for a more intimate contact with the data.

To Dr. John Forster and Dr. Leszek Kosinski for their encouragement and appreciated comments.

To Ilze Hobin who is responsible for the map and line graphs; to James Stafford whose computer program (Poplab Plots) is the source of the population pyramids; to K. P. Krotki, J. E. Krotki, and A. K. Kayani whose program (Stad 3) relieved me of many tedious calculations.

A la Division des Statistiques (Royaume du Maroc), au Bureau du Recensement, et au Centre de Recherches et d'Etudes Démographiques qui m'ont accordé plein accès à leurs personnel, ressources, et facilités.

PREFACE

A preface is that which is written last, printed first, and read least. It may, however, be useful to spell out in these introductory pages the general aim as well as the plan of this thesis.

The study is essentially an exercise in making estimates on the basis of incomplete or inadequate data. Morocco does not have a comprehensive vital registration system through which vital rates are normally calculated. Since these rates, especially those of birth and death, are important facets of a society and almost essential to any type of socio-economic planning, it is important that at least their approximate levels be established. Demographers and statisticians have developed various techniques for situations such as this where population measures are needed while the data that are traditionally used to calculate them are not immediately available. Some of these techniques make use of methods whereby, under certain conditions or assumptions, an appropriate model population can be identified on the basis of some knowledge about a given population so that the relevant features of the model can then be imputed to be those of the given population. This is the type of analysis that is being proposed here for Morocco. The data available are basically two age-sex distributions (1950-52 and 1960) and the implied inter-census growth. It will be argued that the Moroccan population, or at least the overwhelming Muslem majority thereof, generally meets the assumptions required for a stable population analysis. Needless to say, there are various other techniques that could be employed, and estimates have, in fact, been made through other methods, but the present study is, to the

author's knowledge, the first that applies stable population techniques to estimate vital rates in Morocco.

Chapter 1 will give the theoretical background for the analysis. A stable population is a population that is closed to migration and that has constant age-specific schedules of fertility and mortality. Stable population theory holds that when these three conditions are applied over a long period of time the population will become independent of its initial age distribution so that the growth rate and the proportionate age distribution will also become constant. The quasi-stable variant of this theory shows that the mortality condition can be relaxed without greatly affecting the constancy of the resulting age structure. A series of types (based on analytical and empirical generalizations) has been devised whereby knowledge of the structure of the age distribution and of the rate of growth, among other possible pairs of parameters, is largely sufficient to identify the appropriate model stable population whose characteristics can then be imputed to the given population.

The methodology of stable population analysis and of census survival techniques for arriving at similar estimates will be discussed in Chapter 2. Establishing the rate of natural growth and the structure of the age distribution can be problematic. The inter-census growth must be adjusted for migration and for differential under-enumeration among censuses. The age distribution can be distorted by two types of errors which are often difficult to disentangle: misreporting of ages, and age- and sex-selective under-enumeration. The use of ogives (proportions to given ages) as the basis of estimates can largely control for the former type of error. It will be proposed that a detailed study of the age-specific sex ratios, the age ratios, the census survival rates, and the

single-year age distribution can be instrumental both in identifying selective under-reporting and in separating the two types of distortions.

Chapter 3 will present the data and make the adjustments that will be needed before the stable population analysis can proceed. Moroccan census data gathered during the 1950-60 decade are to be used. A brief history of Moroccan censuses as well as comparisons with Algerian and Tunisian age distributions will help to gain insight into the data. As is immediately visible, the Moroccan data contain considerable irregularities. After a review of the various explanations that have been offered to account for the distortions, adjustments are to be made to the growth rate (for migration and for differential under-enumeration among censuses) and to the age distribution (for omissions and for age misreporting). The internal consistency of various segments of the age distribution are to be studied in order to locate those segments that are more trustworthy.

The last chapter will give the analysis and results. Much of this is but a giant exercise in interpolation on the basis of types of life tables and stable populations that have been established as models by Coale and Demeny (1966; 1967, in United Nations Population Study Number 42). Besides stable population, the two other techniques of census survival and of quasi-stable population will be applied in order to make certain comparisons.

Other than the practical utility of deriving estimates for some of the essential features of the Moroccan population, it is hoped that this study will provide an additional demonstration of the usefulness of stable population methods as well as some improvements to the methodology of their application.

TABLE OF CONTENTS

LIST OF TABLES

TABLE NUMBER Page

TABLE NUMBER Page

LIST OF FIGURES

CHAPTER 1

INTRODUCTION TO STABLE POPULATION THEORY

This chapter will provide a general theoretical background to the analysis that is being undertaken. A general explanation of stable population theory will be given as well as a description of its demographic utility. The author, however, will not deal with the mathematical formulae that are involved in the deductive proof of the theory.

As an initial statement, a stable population is a population that is assumed to be closed to migration and that is characterized by constant age-specific schedules of fertility and mortality. When these three conditions have been operating over a long period of time, the population will eventually become independent of its initial age distribution so that the growth rate and the proportionate age distribution will also become constant. Definitions of the terms used above and alternative ways of presenting the theory will be considered shortly.

Before treating the theory itself and as an introduction for the student who is not specialized in demography, a discussion of the interrelations of basic demographic variables in human populations will first be examined. After a brief statement on its historical development, stable population theory will be described along with an explanation of its proof through strong and weak ergodicity. Finally, the semi-stable and quasi-stable derivatives will be considered as well as a short discussion of the utility and limits of this entire development in demography.

1.1 Basic Variables and their Interrelations

The variables specific to demography are actually very limited in number. We could possibly list them as follows: population size, births, deaths, in-migration, out-migration, growth, sex, and age (some authors would add marriage, divorce, and related terms). The rates and ratios that are subsequently developed generally stem directly from this set of variables. Thus a population that is closed to migration can be described by its rates of birth (b), death (d), and natural increase (r) which are taken without regard to age (a), along with age-specific rates of fertility $[m(a)]$, and mortality $[\mu(a)]$ and the proportion of the population between a lower age (a) and an upper age (da); that is, $[c(a)da]$ (Keyfitz, 1968: 174).

The gross rates of birth and death are simply obtained by dividing the total number of births or deaths in one year by the average total population size in that year. Similarly, the age-specific fertility and mortality rates are the result of dividing the births or deaths specific to an age group by the total number in the age group. These rates are often calculated over a certain period and they are often expressed per 1,000 or per 100 population. A schedule of fertility or mortality is the complete set of age-specific rates at one point in time. The rate of increase is calculated on the basis of the rate of compound growth that is needed to derive a subsequent population from an earlier one.

Basically, changes in size and age distribution of a population must be resolved in terms of intervening births, deaths, in-migrants and out-migrants. The effect of migration both on size and on age composition is usually hard to predict due to its variability and its age and sex selectivity. Thus most analytic theory assumes a closed or

isolated population. If we assume that the population is closed to migration, it can be established that change in its age composition over a period of time is contingent on the initial age distribution as well as on the intervening age-specific rates of fertility and mortality. The initial age distribution determines the population at risk of dying and of giving birth, while the age-specific rates determine the rates that are applicable to the various age groups.

The effect of changes in mortality and fertility on age distribution and the importance of the initial age distribution deserve special consideration. The effect of a decline in mortality, or of an increase in life expectancy, is generally not that of increasing the proportions at older ages as one would tend to expect. The important generalization to retain in this regard is that declines in mortality usually affect all ages thus increasing the number at all ages with little effect on the proportionate age distribution. Coale (1956) has demonstrated that there are three components to a typical pattern of mortality decline. The first, as mentioned above, is independent of age. The second component tends to bring infant and early-childhood mortality down disproportionately to that of the other age groups. Thus a mortality decline that is strong in this component will tend to make the population younger both because there are proportionately more survivors at younger ages and because there will eventually be proportionately more adults in the reproductive ages with, again, more births. While the second component is typically predominant when mortality is declining from initially high levels, the third component, which affects the older segments of the population disproportionately, becomes predominant in later stages of mortality decline. This is understandable in the sense

that mortality rates eventually become so low for the younger segments that further improvements are progressively less possible and the majority of improvements must take place at older ages. In this case, the population becomes older, but again there would be a limit in the extent to which the mortality of older segments can be improved. The effect of fertility change on age distribution is both simple and radical because it affects the entire base of the pyramid. Thus it must be emphasized that declines in fertility will invariably make the population older and that it is the past history of fertility that is most adequately reflected in the population pyramid.

With a short time span between two age pyramids of the same population, the initial age distribution will have an imprint on the subsequent one for two reasons. Firstly, the cohorts (group of people belonging to the same age group) that were present in the first instance will retain through life much of their proportions to each other while moving up in the hierarchical arrangement of the age pyramid. Secondly, the proportionate size of the cohorts in the reproductive ages is important in determining the size of the birth cohorts. Preston (1970) has shown that in populations characterized by rapid growth (3% per year) the contribution of age composition to that growth is about one-quarter to one-third of the total. Dublin and Lotka (1925) had noted that previous high fertility can thus, through the age distribution, alleviate the effects on crude birth rates of subsequent fertility declines. The realization that the distinction made here is really between the contributions of past and current fertility is a key to the subsequent presentation of stable population theory.

1.2 Historical Development of Stable Population Theory

The life table was an important antecedent to stable population theory. Graunt (1662) developed the necessary conceptual scheme and schematic design while Halley (1693) constructed the first empirical life table. Such a table, which gives the varying chances of dying as a function of age, is important in this context for three reasons. First, it relates vital events, in this case deaths, to the various age groups of the population at risk. Second, it is an attempt to control for the particular age distribution of a population when measuring its vital rates (the expectation of life is a measure which is independent of the age composition). Third, the l_x (survivors at age x) column of the life table can be viewed as a stable population. In the hypothetical instance of a population actually corresponding to this l_x column, this life table population would be both a stationary population and a stable population with zero growth rate. This becomes understandable upon the realization that such a fixed age composition would be arrived at if there was a constant addition of births (usually 100,000 of each sex) per year and if the schedule of age-specific mortality rates remained constant at the levels used to calculate the life table.

Euler (1760) took a second major step in developing the basic principles of a "stable" population (though he did not use this word). He essentially showed that a closed population with a constant schedule of age-specific mortality and a constant rate of increase must have a fixed age distribution (Lorimer, 1959: 151). Though he did not bring in the question of fertility schedules, his presentation speaks to the essence of the theory.

Lotka brought the theory to a more precise form and contributed the first deductive proof of its validity. In an initial article (1907), he considered the mode of growth of systems where the "life period" of each individual element may be limited but where the aggregate of a number of such individuals has a prolonged existence. The fundamental feature of the method developed was the splitting up of the characteristics governing the rate of growth of the material aggregate into two factors--the one relating to those properties of the system which determine the formation of new individuals, and the other relating to those properties of the system which determine the limitation of the "life period" of the individual constituents. Sharpe and Lotka (1911) later developed the fundamental equation which indicates the limiting type towards which a closed population tends to evolve under constant conditions. A definitive statement of the complete theory is to be found in Théorie Analytique des Associations Biologiques (Lotka, 1934-39).

More recent developments in the theory have taken two directions: development of the abstract aspect of the theory with the use of the mathematics of self-renewing aggregates (Lopez, 1961; McFarland, 1969) and application of the theory to problems of estimates (Bourgeois-Pichat, 1958; U.N., 1968: Population Study Number 39; U.N., 1967: Population Study Number 42).

1.3 Presentation of the Theory

As has already been said, stable population theory seeks to discover certain necessary relations among demographic processes under specified conditions. It could be called an analytic theory in the sense that it can be developed in abstraction of any given population and that it aims

at the discovery and formulation of structural relations inherent in the nature of biological aggregates (Lorimer, 1959: 149). It is a theory in the sense of a deductively connected set of propositions.

It was emphasized in the first section of this chapter that the age distribution and growth rate of a closed population depend both on the age-specific schedules of fertility and mortality and on the particular structure of the age distribution to which they have been applied. However, stable population theory states that under conditions of constant schedules the rate of increase and the proportionate age distribution will ultimately become both constant and independent of the initial age structure. The equation which can be shown to derive under such conditions is the following:

$c(a) = b\ e^{-ra}\ p(a)$[1]

where: $c(a)$ = proportion of the population at age "a"

b = constant birth rate

r = constant rate of natural increase

$p(a)$ = proportion surviving to age "a"

e^{rx} = factor expressing exponential growth at rate "r" for "x" years.

---

[1]This equation can be derived as follows (under constant conditions):

$c(a) = \frac{B(t-a)}{N(t)}\ p(a)$, where: $B(t-a)$ = total births at time interval t-a

$N(t)$ = total population at time t

$B(t-a) = b\ N(t-a)$, where: b = births per head

$= b\ N(t)\ e^{-ra}$, which means that the total is decreased exponentially to time interval t-a

Thus, $c(a) = \frac{b\ N(t)\ e^{-ra}}{N(t)}\ p(a) = b\ e^{-ra}\ p(a)$.

This equation states the fundamental relations inherent in a stable population linking the age distribution, the survivorship function, the rate of growth, and the crude birth rate (Bourgeois-Pichat, 1971). The formula also indicates that the age distribution which results from a sufficiently long period of constant rates is not dependent on the initial age distribution. It should be noted that these equations are generally applied separately for each sex.

Bourgeois-Pichat (U.N., 1968: Population Study Number 39) has shown that there are three ways of classifying the universe of stable populations, each on the basis of two known and constant variables and one additional condition. These sets are the following:

(1) constant and known survivorship function,
constant and known rate of growth,
constant but not known age distribution;

(2) constant and known age distribution,
constant and known rate of growth,
constant but not known survivorship function;

(3) constant and known age distribution of deaths,
constant and known growth rate,
constant but not known survivorship function and age distribution.

In each of the above circumstances, the unknown parameters can be calculated on the basis of formulae derived essentially from $c(a) = b\, e^{-ra}\, p(a)$. Also, a series of alternative parameters can, if known, be substituted for the growth rate in the above sets to derive, once again, the other parameters.[2]

---

[2]Using a slightly different approach, Keyfitz (1968: 174-82) developed seven alternative sets of two known characteristics on the basis of which the stable population may be determined.

1.4 Weak and Strong Ergodicity as Avenues for Proof of the Theory

Ergodicity is the characteristic of those stochastic processes (systems that contain a random variable) which ultimately approach their theoretical values. In the demographic context, weak ergodicity is the process by which a population, if subjected to a set of age-specific vital rates with these rates possibly varying over time, will eventually "forget" its initial age distribution. That is, after a sufficiently long period of time, the age distribution essentially depends only on the history of age-specific vital rates (McFarland, 1969: 302). This theorem was conjectured by Coale (1957) and later proved in slightly different ways by Lopez (1961) and McFarland (1969). The proof is based on rather simple assumptions: two populations, each of one and the same sex, which have initially different age distributions but are subjected to identical age-specific vital rates over a long period of time; these rates each must have an upper limit; they also have a lower limit above zero; the populations are closed to migration; and a Markovian process (that is, vital rates of one generation do not depend on those of the individuals' specific ancestors). The essential ideas behind the proof are twofold: each cohort eventually dies, thus relieving the age distribution of its particular distortion; and there is an overlap of the generations by which cohorts replace themselves so that a "smoothing" effect is involved.

Weak ergodicity is therefore sufficient to prove that the population eventually becomes independent of its initial age structure and dependent only on intervening vital rates. Strong ergodicity adds the assumption that intervening vital rates are constant. In this case,

the population will evidently also "forget" its age distribution in the remote past. Also, the resulting age distribution will be constant because it depends solely on constants (the vital rates).

1.5 Semi-stable Population

As has been repeatedly said, a stable population is only arrived at after a certain time lag during which period constant schedules are operating. The precise length of this time lag depends essentially on three factors: the exactitude of the approximation required, the degree of irregularity in the initial age distribution, and the constant rates used (especially the extent of their deviation from rates that were previously operating in the population). Bourgeois-Pichat (U.N., 1968: Population Study Number 39: 3-9) developed certain examples of this process using as initial populations those of Eastern Germany and Thailand in 1955. In spite of the irregularity of the East German age distribution and the discontinuity of the rates applied to the Thailand population, almost identical stable populations were found to result after constant age-specific rates had been applied for eighty to one-hundred years.

But there are instances where this time lag is much shorter. Populations for which this time lag is zero, and which thus actually have constant age distributions, have been named semi-stable. A semi-stable population could then be defined as a population that evolves naturally within the universe of stable populations so that it continuously retains the same relations among fertility, mortality, natural increase, and age distribution as are obtained in stable populations. Since we have previously established a closed system between fertility, mortality, and age distribution, this is but a different way of looking at the same relations.

Thus a population with a constant age distribution coincides at any point of time with the stable population corresponding to the survivorship function and the female fertility function at that point (Bourgeois-Pichat, 1971: 239-40). It is not claimed that the mortality and fertility functions are constant (thus it is not, strictly speaking, stable) but simply that there obtains at each instance between the demographic characteristics of the population approximately the same relations as in a stable population.

Since there exist many actual populations that have age structures which, while not absolutely unchanging, change only slightly, this enables us to make direct applications of stable population formulae to calculate, on the basis of two known parameters, the other demographic characteristics. There are limitations to such applications in that the data available are usually discrete and they must be transformed into a continuous form in order to use the formulae. Also, the method is very sensitive to inadequacies in the data; for example, a small emigration or selective under-enumeration in the 20-29 age bracket will show up as a high mortality factor for these ages.

1.6 Quasi-stable Population

Up to this point, we have mainly been concerned with the development of a general analytic structure that links various demographic characteristics under specified conditions. This analytic theory could be viewed as an ideal model which would seem to have little applicability in the real world. However, the conditions of semi-stable populations are already generalizations that have been closely approximated by actual demographic evolutions.

The operationalization of the theory has been greatly enhanced by the discovery, based on empirical findings, that one of the assumptions of the theory can be weakened without having more than a negligible effect on the theory's conclusion. It was found that the condition of stable mortality could be relaxed and that the age distribution would generally remain stable. Thus, if the fertility schedule of a closed population has been constant over a long period of time, this condition is largely sufficient to establish a stable age distribution. The conditions thus stated apply to a large portion of the populations of developing countries. Two empirical generalizations have enabled us to arrive at this quasi-stable derivative of the theory: mortality does not greatly affect the age distribution; and mortality declines have a typical pattern that can be described in terms of model life tables. There is no logical necessity that mortality differences should produce only minor differences in the stable age distribution (Coale, 1957: 85). It is, rather, an observed phenomenon the basis of which has been discussed earlier. It can, in fact, be shown mathematically (Keyfitz, 1968: 185) that an across-the-board drop in mortality has absolutely no effect on the stable age structure. As is explained by Bourgeois-Pichat (U.N., 1968: Population Study Number 39: IX), when a population is assimilated to a semi-stable population the little variation in its age structure is interpreted as the imperfect materialization of an invariable age distribution; while when a population is assimilated to a quasi-stable population the little variation in its age structure is interpreted as the materialization of a population with constant fertility but with a mortality varying over the possible range of human mortality. Thus, though mortality is not assumed to be constant, it is

assumed to be varying within a range of empirically constructed model life tables. Eight main families of these tables have thus far been established: the intermediate model (U.N., 1955: Population Study Number 22); the upward and downward deviating networks (U.N., 1968: Population Study Number 39); the North, South, East, and West families (Coale and Demeny, 1966); and a Brass model (Brass, et al., 1968: Chapter 3). Each of these families uses a series of real life tables to generalize a typical age pattern of mortality that does not depend on the over-all level of mortality. That is, within a family, mortality decline would simply range within levels (of life expectancy) without greatly changing in age pattern. Each family is slightly different in its age pattern; thus, for example, the East family is characterized by very high mortality rates in infancy and in ages over fifty. Once these models have been established, it is a simple matter of combining a life table with a rate of increase to obtain a stable population with a determinate age composition and the associated birth and death rates.[3] Coale and Demeny (1966) have developed nearly 5,000 such stable age distributions on the basis of the twenty-four model life tables (levels of mortality) in each of their four families of life tables.

Assuming a closed population with constant fertility whose mortality schedule belongs to a family of life tables, it is now possible to find among these stable age distributions the one that corresponds to the given actual population. The characteristics of the model, especially the birth rate and death rate, can then be inferred to be those of the

---

[3]The previously presented formula, $c(a) = b\, e^{-ra}\, p(a)$, is used with b derived at: $b = \dfrac{1}{\int_0^w e^{-ra}\, p(a)\, da}$

given population. Two parameters are needed to choose an age distribution and its associated characteristics; any non-redundant pair among the following values could be used (Coale, 1963: 176-77):

(a) Age distribution measures, such as the relative proportion of two different parts of the age distribution, or of one part to the whole;

(b) Mortality measures, such as the expectation of life at any age, the proportion surviving from one age to another, an age-specific mortality rate, or the crude death rate;

(c) The rate of growth of the total population or of any broad age group;

(d) A measure of the fertility of the population, such as the crude birth rate, the general fertility rate, or total fertility plus the mean age of childbearing.

The more explicit methodology of applying this procedure to make estimates about a population, as well as the problems that can be encountered, will be discussed in the following chapter.

1.7 Utility and Limits of the Theory and of its Derivatives

For the sake of completion, a few of the additional uses of the theory should be mentioned. Intrinsic rate is a concept that derives from stable population. It was introduced as the "true rate of natural increase" by Dublin and Lotka in 1925. Intrinsic vital rates are those that would result if the present schedules of fertility and mortality were to continue permanently so that the age distribution would have adjusted itself to these constant biological conditions. It is a way of adjusting crude vital rates by making them independent of current distortions in the age distribution. However, these intrinsic rates still are subjected to the deficiencies of being based on a synthetic cohort (that is, we are assuming that the present experience of the people at

the various ages can be equated to that of the various real cohorts of age groups as they pass through these ages). This becomes problematic when vital rates, especially fertility, fluctuate in either a cyclical or secular fashion. Another problem of the theory that becomes evident in regard to intrinsic rates is that of considering the two sexes separately; in some cases, this can lead to a distorted sex ratio which would normally hamper reproduction.

The various stable population models can be used to illustrate relationships among demographic variables especially under artificially controlled conditions. LeBras (1969; 1971) has been using the model to study the return of populations to a stable state after a catastrophe and to draw inferences from certain "unstable" populations. But the main utility of the theory and of its derivatives is probably that of making estimates on the basis of scanty data. The limitations here are in regard to the assumptions that are required and the deficiencies of those parameters in the given population used for making the estimations.

To recap briefly the substance of this chapter, we have started with a very limited set of variables that are relevant to the replacement of populations. The question of age distribution was brought in, which both refined the categories and made the matter more complex. A set of strong assumptions were then imposed to study the relations among these fundamental variables. An analytic or deductive theory was developed indicating that a population eventually becomes independent of its initial age distribution. Then, a combination of these analytic generalizations and of certain empirical generalizations enabled us to weaken one of the assumptions in the ideal model without greatly influencing its conclusions. This introduced a series of types (based on

analytical and empirical generalizations) which were found to have considerable applicability to the real world.

CHAPTER 2

METHODOLOGY

The development of methods for measuring errors, and for making adjustments to eliminate their effects, as well as the development of ways of making estimates on the basis of data of dubious validity are important aspects of the development of demography as a science.

Some of these methods as relevant to the data available on the Moroccan population will be discussed in this chapter. These data, which will be presented more systematically in the following chapter, involve essentially two age-sex distributions separated by some eight to ten years. The estimates that we especially wish to derive are those of the birth and death rates.

The plan of this chapter is as follows: presentation of the census survivorship method and of the stable population method; procedures of correction for destabilization, for age misreporting, and for selective under-enumeration; a discussion of the prevalence of these last two types of errors; brief abstracts of case studies involving these various methods including a statement on how the researchers dealt with the issue of misreporting versus under-enumeration; and finally an outline of the procedures chosen for this study. Since the discussion that is being undertaken is rather tedious, the reader may want to anticipate its conclusions (Section 2.8).

Needless to say, there are various other methods available for making estimates of vital rates on the basis of incomplete data.

Notable among these are the Brass techniques which use data from survey questions on fertility and mortality. These, however, will not be discussed in this context since the data to be used in this study are of a different order.

2.1 Census Survival Method

This method is a rather straightforward procedure for estimating vital rates when two series of five-year age distributions, separated by five or ten years, are available for a given population. The essential idea is that various life table measures, thus the death rate, can be calculated by looking at the proportions of the various age groups who survive to the subsequent census. Then, on the basis of the inter-census growth rate, the birth rate can be calculated as a residual: $r = b - d$ (the rate of natural growth is equal to the birth rate minus the death rate).

Coale and Demeny (U.N., 1967: Population Study Number 42) give an excellent presentation of the steps involved in deriving these estimates. If the two censuses used had achieved accurate coverage of the population and if the ages were accurately reported, it is evident that life table measures for ages above five could be calculated directly. The use of model life tables enables us both to extend the estimates to the entire population and to make use of less accurate data. As was noted in the previous chapter, model life tables are based on the fact that mortality risks experienced by different age-and-sex defined segments of a population are interrelated.

The procedure suggested is as follows. First, adjustments must be made for migration. This is necessary because out-migrants would otherwise appear as deaths and in-migrants as "recoveries." The method could

not be used in the instance of strong migration unless the age-sex characteristics of the migrants were known so that the population could be artificially closed. After adjusting for migration, the population of unknown ages is distributed over the various age groups, usually assuming that it has the same age structure as the recorded population. The question of differential under-enumeration among the two censuses used should also be considered, since it will affect the survival rates. If this differential under-enumeration is known, adjustments should be made. Age- and sex-selection omissions do not bother this analysis as long as they are of the same proportion in both censuses. However, if there is evidence of differential selective omissions between the censuses, such errors would affect the estimates and adjustments should be made.

A model life table consistent with the observed survival rates of the various age groups can now be selected. If each age group is used separately, there will often be a wide range in the model life tables implied by the various survival rates due to misreporting of ages. It is therefore suggested to determine the level of mortality on the basis of the survivorship of large segments of the population: the proportion surviving from the entire earlier population to age ten and above in the later censuses, the proportion five and above surviving to fifteen and above, and so on.[4] Practically, this is done by projecting, through the application of the survival rates implied by the model life tables at various levels of mortality, the relevant age groups of the first census to their counterparts in the second census. The proportion actually surviving is thus eventually encircled between two levels and the exact

---

[4]If the censuses are separated by five years rather than ten, the groups used must evidently be separated by five years.

level is calculated by interpolation. Coale and Demeny (U.N., 1967: Population Study Number 42) suggest that the researcher should choose the median level implied by the first nine of these projections. The survivorship functions considered would then be the following: entire population of the first census to population ten and above in the second census, population over five to population over fifteen, . . ., population over forty to population over fifty. The model chosen in this way permits the estimation of the death rates for each age group, including 0-4. These rates are then applied to the interpolated mid-census population to obtain total deaths and thus the over-all death rate. This can either be done separately for each sex or for only one sex, in which case rates for the other sex assume the same level of mortality.

The procedures thus outlined help considerably to minimize estimation errors. However, two other sources of inaccuracy should be mentioned. It has been noted that there are several families of model life tables. Since the data available generally do not permit the researcher to decide which family should be chosen, errors can arise from the choice of an inappropriate family. This error affects mainly the death rates of ages 0-4, since the proportion of deaths in these ages vary considerably among families. This inaccuracy will also affect the calculated life expectancy at age zero and the birth rate. Coale and Demeny (U.N., 1967: Population Study Number 42: 42) note that variations among families of life tables can affect the assumed birth rate by as much as 11% and that the assumption of the West pattern of mortality produces conservative estimates of the vital rates. The other source of inaccuracy is that of unrecognized differential rates of omission in the censuses used. Since coverage often improves with time, this would

produce an under-estimate of the death rate (recoveries increase the survival rate) and an over-estimate of the inter-census growth rate. However, these errors would, at least partly, compensate for each other in the calculation of the birth rate ($b = r + d$).

2.2 Stable Population Method

The estimation of vital rates by the stable population method involves, essentially, selecting a model stable population on the basis of at least two known parameters of a given population. The parameters that will be used in this study are the inter-census growth rate coupled with some age distribution measure. The vital rates of the chosen model are then assigned to the given population.

If the conditions required of a stable population are insured (no migration, constant schedules of fertility and mortality), if the appropriate family of life tables is known, if the growth rate is accurate (complete coverage by both censuses), and if the ages were accurately recorded in the second census, various alternative features of the age distribution can be used along with the growth rate to locate (possibly through interpolation) the appropriate model among those tabulated in Coale and Demeny (1966). Each of these models is associated with various parameters, the most important of which are the birth and death rates. As with the census survival method, the procedure can either be applied to each sex separately, or it can be applied to one sex and estimates derived for the other sex through the sex ratios at birth and the sex ratio in the enumerated population. Adjustments and corrections that can be made in the eventuality that some of the conditions mentioned above do not apply will be considered in the three following sections of this chapter. Let it be said at this point that adjustments for migration

and for unknown ages are identical to those used in the census survival method.

The author would like to discuss first some of the inaccuracy that can result in the eventuality that some of the specified conditions do not apply. Errors can arise from differences between the actual age pattern of mortality and that embodied in the chosen family of life tables. The appropriate family is rarely known; and, furthermore, there is no reason to believe that the established families encompass the whole variety of patterns (Coale, 1963). In fact, no models have been devised for Africa. These variations among families do not greatly affect estimates for ages above five. However, the estimated crude birth and death rates per thousand can vary by as much as six points due to variations among the four Coale-Demeny families (Coale, 1963: 179).

Errors can also be made if a population that is quasi-stable is assumed to be stable. Coale and Demeny (U.N., 1967: Population Study Number 42: 46) have calculated that if there has been a strong decline in mortality but the population is assumed to be stable, the estimated rates can be in error by as much as 8.5%. It is encouraging that the direction of this error has been established (Coale, 1963; Demeny, 1965; U.N., 1967: Population Study Number 42): the assumption of stability in the actual condition of quasi-stability causes an under-estimate of the vital rates.

As in the census survival method, errors can result from differential rates of omission in consecutive censuses. However, the errors here do not tend to compensate. In the usual case of improved coverage, the growth rate used will be too high. This in combination with an age distribution will make for the choice of a model whose associated birth

rate is an under-estimate of the actual birth rate (this under-estimate is of about the same magnitude as the error in the growth rate). The death rate now becomes the residual (d = b - r) so that its under-estimation is about twice as much as that of the birth rate (U.N., 1967: Population Study Number 42: 49). Bourgeois-Pichat (U.N., 1968: Population Study Number 39: 97) argues that stable population methods can establish birth rates more firmly than death rates. This can be understood since variations in mortality have little influence on age structure, whereas variations in fertility have a great deal of influence. It follows that the inexactitude of the observed age structure has little effect on estimates of fertility but makes estimates of mortality more uncertain.

2.3 Correction for Destabilization (Quasi-stable Population)

In spite of the relative insensitivity of age distributions to changes in mortality, Coale (1963) noted that a history of declining mortality does have a noticeable effect in causing the quasi-stable population to deviate from the stable population if the down-trend has continued to the moment of comparison. He isolated as factors in this decline that affect the age distribution and its associated vital rates: the rapidity of the decline, the time since it began, and its recent persistence.

Demeny (1965) constructed a series of tables to establish the direction and the quantitative significance of the resulting bias in the vital rates. He did this by computing population projections that simulate particular processes of destabilization. To the three factors isolated by Coale he added a fourth one: original level of mortality.

It was found that the higher the initial level of mortality, the larger will be the deviations in the process of destabilization. Demeny admits that the use of the devices presented to adjust for destabilization will generally require information that is seldom available. These devices and accompanying tables, however, can help to avoid serious errors of interpretation.

In their how-to-do-it Manual (U.N., 1967: Population Study Number 42: 25-28), Coale and Demeny propose that the initial level of mortality can be neglected when making adjustments for destabilization. If mortality decline is continuing to the present, any indication of the duration and pace of this decline will enable the researcher to account for most of the differences between stable and quasi-stable conditions in his final estimates. This procedure is based on the rate of mortality change which can be derived from, among other possible measures, the absolute change in the rate of growth of the population and the time span of this change. Tables have been devised to take account of this mortality change. The important thing to retain is that the principal effect of declining mortality on age composition closely resembles the influence of steadily rising fertility. Thus, not taking destabilization into account will slightly under-estimate fertility (and, consequently, it will also under-estimate mortality).

2.4 Correction for Misreporting of Ages

Age misclassification is a common feature of inadequate data. However, its effects on estimates can be greatly dampened by the technique of cumulation. Only the misreporting at the boundary age(s) can affect an estimate that is derived from a cumulated age group. Though this technique has been in use for some time [Bourgeois-Pichat, 1958,

used the proportion (5-14)/5+], the details of its application have been most clearly specified and most strongly promoted in the U.N. Manual (U.N., 1967: Population Study Number 42). The emphasis of methods suggested in this Manual is switched from traditional five-year age groups to whole blocks of respondents below or above a certain age (ogive). The important characteristic of these cumulated proportions in regard to choosing a model stable population is that within a family of stable populations and within a given growth rate these ogives do not cross each other. Thus, such an elementary measure of the age distribution as the proportion to a certain age (say age 35) is sufficient, when coupled with a growth rate, to identify the appropriate model. Those populations with a higher proportion to this age will have higher fertility and those with a lower proportion will have lower fertility (with a given growth rate).

The Manual suggests that models be identified on the basis of each of the first nine cumulated age groups of a given population (that is: 0-4, 0-9, 0-14, . . ., 0-44) and that either the median level indicated by these proportions be chosen or, when misreporting is excessive, confidence be placed on the estimate derived from the proportion 0-9 and especially the proportion 0-34. This proportion to age 35 is preferred, especially for females, on the basis that in the experience of many countries with inadequate data little misreporting takes place across this age.

Demeny and Shorter (1968) devised a technique whereby the pattern of misreporting can be identified if a series of quinquennial or decennial censuses are available. The assumptions imposed are the following: the survival rates are those of a selected mortality model, the pattern

of misreporting is systematic among censuses, and the total size is correctly enumerated. The procedure essentially involves projecting the age groups from one census to the next and noting the adjustments that are necessary. It can then be decided which cohorts are actually unusual in proportionate size and which are unusual only because of systematic misclassification. The assumption of complete enumeration, however, is heroic and dangerous. This is the topic of the next section.

2.5 Correction for Age- and Sex-selective Under-enumeration

Another aspect of inadequate data that can often affect estimates through stable population techniques is that of omissions. If the relative age and sex structure of the omitted population corresponds to that of the enumerated population, then it is as if we had obtained a random sample so that age structure itself is not affected. If this be the case, the estimates would only be affected if this "random" omission was different among censuses. In the case of differential under-enumeration (among censuses), the calculated growth rate is evidently affected and any indication to this effect should be used in adjusting the growth rate.

But a more serious problem arises if under-enumeration is age- and sex-selective. This is particularly problematic in that it is very difficult to disentangle the effects of selective under-enumeration from those of misclassification. Faced with this difficulty, many researchers have chosen to assume that one of the types of error does not apply and thus they proceed to make corrections only for the other type of error. The U.N. Manual makes the implicit assumption that omissions affect primarily the total number of persons enumerated and that the distorted age composition is caused by misreporting of ages. It can in fact be argued

(Coale, 1963; Romaniuk, 1967) that cumulation of age groups also minimizes the effect of selective under-enumeration. This is understandable in the sense that cumulation causes the under-enumeration to be spread out over a larger segment with a possibility that it be equal among the chosen segments. If the selective under-enumeration below and above the chosen dividing age is of the same order, the estimates will not be affected. Krotki (1969) has argued that such an assumption is not valid because most under-enumeration takes place at younger ages. Neglect of selective under-counting thus leads invariably to lower estimates of fertility (and, with a given growth rate, to lower estimates of mortality) than estimates which admit the possibility of age- and sex-selective under-enumeration. It was calculated that a relative under-enumeration under age thirty-five of two-and-a-half or five per cent could lead to under-estimates of vital rates in the order of six and fourteen points per thousand, respectively.

It is therefore necessary to consider ways by which such under-enumeration can be detected and subsequently accounted for in the analysis. Such techniques have generally been developed on an ad hoc basis in dealing with particular populations and the data available. The surest way to check for omissions is to compare census figures with those obtained in a totally independent fashion. Thus, for example, if highly accurate vital registration and migration data are available, the numbers that should be at the various age groups can be calculated.

Coale (1955) has demonstrated that a limited amount of information about errors can be obtained by checking the internal consistency of the census data itself. In Coale's analysis of the U.S. censuses of 1930 to 1950, he first took note of this evidence of inconsistency as made evident

by distortions in the following measures: the sex ratios of the various age groups, the age ratios (proportion of a given age group relative to the average of its two adjoining age groups), and the single-year age distribution (age heaping). Proceeding then on the hypothesis that recent censuses are subject to similar errors, he first estimated the errors in age groups 0-4, 5-9, and 10-14 in 1950 on the basis of vital registration data. The assumption of similarity then enables him to estimate errors in the earlier censuses at these same ages; finally, cohort changes combined with known errors in the earlier census permit the estimation of errors at later ages in the later census, and so on. It was found that the figures adjusted in this way implied more internal consistency--except at higher ages. We could note in passing that this procedure is very similar to the one presented above by which Demeny and Shorter (1968) estimated age misreporting.

Data of the order required in Coale's analysis are generally not available in countries for which basic estimates are required. Krotki (1963) carried out an analysis on the population of Pakistan where under-enumeration is estimated on the basis of two age distributions (1951 and 1961). He starts with the assumption that a population like that of Pakistan must show considerable regularity in its age distribution since the distribution is shaped primarily by fertility which has remained constant at high levels. The author then makes extensive use of the proportions surviving in the various age-sex groups from 1951 to 1961 to establish instances of "recoveries" and "omissions" at the various ages for each sex. He concentrates on those age groups which require the least amount of adjusting and which also fit a consistent set of arguments in regard to possible under-enumeration. At the same time, reasons

are put forth for not accepting other age groups which would require still larger adjustments. Final adjustments gain additional plausibility because of the improved internal consistency and over-all sex ratio which they imply.

This general procedure was again applied by Krotki and Thakur (1971) to the population of Nepal. These authors made a systematic analysis of sex ratios, age ratios, census survivorship rates and the single-year age distribution, in each case gathering evidence of possible misreporting or selective under-enumeration. In their adjustments, they give maximum weight to arguments for misreporting and generally only assume under-enumeration when the alternative type of adjustment would require almost impossible assumptions. Two firm rims are established in the age distribution (age groups 5-9 and 25+) and the other ages are filled in by comparison to a population that has the same relation between these two age distribution measures.

2.6 Prevalence of Misreporting and Under-enumeration

It was argued at the beginning of the previous section that the actual separation of the effects of misreporting and under-reporting in a given population is a difficult task. The whole question of the extent to which one should rely on an enumerated age distribution is a serious debate in demography.

A good entry into this discussion may be through what has been called the Keyfitz-van de Walle controversy. In an article on Indonesia entitled "Age Distribution as a Challenge to Development," Keyfitz (1965) took the age distribution seriously and argued that the entrants to the labor force would double in the next five years. He looked especially at the relation between age groups 0-9 and 10-19 as enumerated in 1961

and found evidence that the latter group was relatively small. This could be explained in terms of the revolutions of the 1940's as compared to the peace and relative prosperity of the 1950's. Keyfitz argued that the absorption into the labor force of this group, which in 1961 was aged 0-9, could well be a difficult operation for the Indonesian economy.

In a study of characteristic features of census age distributions in illiterate populations, van de Walle (1966) compared a series of census data from Tropical Africa to that of Indonesia and noted that the irregularities uncovered by Keyfitz were in fact common to many illiterate populations. In discussing why this bias should be systematic, he argues that there are various patterns of age misreporting common to these countries. In a later article, van de Walle (1968) puts forth certain propositions to explain the "Characteristics of African Demographic Data." He brings the problem down to that of trying to record the ages of people who do not know their exact ages and are not fundamentally interested in knowing them. Ages are therefore often estimated by the interviewer. On the female side of the age distribution there is generally a deficiency at ages 10-14 paired with excesses at 20-40 and especially at ages over 65. On the male side, the persons in their teens seem to have their ages under-estimated, while adult males to age 35 are missing. Though van de Walle recognizes that these distortions could be due to both differential age misreporting and omissions, he tends to put emphasis on the former except for young adult males. There would be a tendency for the enumerator to decrease the ages of children who have not reached puberty. Also, there would be a tendency for interviewers to systematically age those women who are already married or mothers, starting from a supposed age at marriage and a standard interval

between births. The bias would be initiated by assuming a higher "typical" age of marriage than actually prevails.

Coale and Demeny (U.N., 1967: Population Study Number 42) have taken up essentially the same arguments in their discussion of characteristic forms of age misstatement. By comparing over 150 populations of each sex with a chosen stable population, they claim to have identified two general patterns of age misreporting. The one would be characteristic of African and Asian populations and would be essentially as described above. The other is the Latin American pattern where the age is generally given by the respondent and where there is less systematic distortion over large age groups but much age heaping at certain preferred ages. They also note that the male distortions, which on the average are larger, show less similarity among countries.

But, as indicated earlier, the Keyfitz-van de Walle controversy does not cover the whole range of possibilities. Also, as both authors recognize, the issue of whether or not the distortions are real can ultimately be resolved when subsequent censuses are available. But the issue of selective misreporting versus under-enumeration still cannot be resolved in this way. The already noted similarity of methods proposed by Coale (1955) and Demeny and Shorter (1968) to deal with the opposite problems is evidence to this effect.

The under-enumeration of young children is a feature of censuses and surveys that has often been noted. Thus Bourgeois-Pichat (U.N., 1968: Population Study Number 39) suggests that the age group 0-4 should sometimes be left out of the analysis. Coale (1955) has put forth a consistent argument for under-enumeration in the United States; this under-enumeration would tend to concentrate on young children and on

adult males--especially in the non-white population. Krotki's (1963) analysis of Pakistanian data stresses under-enumeration of children, of females starting at age 5-9, and of men especially at 20-24. Similarly, in Nepal (Krotki and Thakur, 1971), the main deficiencies were in ages 0-4 for both sexes, 10-19 for females, and 15-24 for males. These deficiencies have sometimes been explained in terms of the lack of importance placed on young children, the desire to hide young marriageable or newly married females, and the high mobility of the young adult male. As a last example, Coale and Hoover (1958: 354, 368-69) suggest an under-count of children 0-4 and of females in India for a total under-enumeration of some 5.0 to 6.5 per cent, as well as an under-count of children 0-4 and of males 10-35 in Mexico for a total under-enumeration of some 3.5 per cent.

2.7 Some Case Studies

Though reference has already been made to most of the studies listed below, the author thought it would be useful to include short summaries of some of the major applications to specific populations of the methods outlined in this chapter. The list is chronological in order.

Coale (1955): This is essentially a revision of U.S. census figures for 1950. Emphasis is placed on under-enumeration with final estimates indicating 3.6% under-enumeration (five million). The figure for the non-white population rises to 12-13%. A method is presented for estimating under-enumeration when at least two censuses separated by five or ten years and reliable vital registration data for the last five to fifteen years are available.

Bourgeois-Pichat (1958): Colombia and Chile are given as examples. Use is made of census survival methods and stable population formulae, including those dealing with age at death, to estimate vital rates. The author tends to exclude age group 0-4 from the analysis due to its under-enumeration; thus in the stable population method he uses the proportion (5-14)/5+ to characterize the age distribution.

Abdel-Aty (1961): Life table functions are derived for Egypt using model life tables (U.N., 1955: Population Study Number 22) and quasi-stable population theory. The life table so established is used to adjust the age distribution and subsequently to derive vital rates. Age group 0-4 is left out due to under-enumeration.

Coale and Zelnik (1963): An extension of the Coale (1955) analysis to U.S. censuses of 1880-1950. Extensive use is made of the single-year age distribution and of projections from vital registration data to estimate the population at the census dates. The lowest under-enumeration is found to be that of females 15-29.

Krotki (1963): The 1961 census of Pakistan is first analyzed for under-enumeration especially using survival measures of the cohorts that were also enumerated in 1951. The under-enumeration, all below age 25, was found to be 8.2% (eight million). The estimate so established was subsequently used as the official figure for the population of Pakistan. The vital rates are derived from the adjusted age distribution.

Keyfitz (1965): The age distribution of Indonesia, especially the proportion (0-9)/(10-19), is taken to indicate changes in conditions of health, peace, and prosperity and to be a challenge for the economic

development of the country.

Kim (1965): An analysis of the war losses in Korea through stable population methods. After adjustments for migration, it is found that census data for 1925-1940 are accurate. The stability of the age distribution over this period is used as evidence of the applicability of stable population methods. Life table functions are derived from stable population formulae and also using the following age distribution measures: (5-14)/5+ and (0-4)/(15-44).

Coale and Demeny (1967: U.N. Population Study Number 42): Examples for India, Brazil, and Mexico are used in demonstrating stable population techniques. Adjustments are made for misreporting but not for selective under-enumeration.

Romaniuk (1967): In estimating birth rates for the Congo, the author finds that he can have high confidence in the age reporting of group 0-4. Fertility is estimated by stable population methods (using the proportion at ages 0-4) and by various Brass methods which use data from survey questions. It is claimed that, although some under-reporting may have contributed to the deficit among adolescents, the observed disturbance in the age distribution is due largely to systematic age misclassification.

Demeny and Shorter (1968): The stable model is found not to be applicable to Turkish data due to severe disturbances affecting vital rates. Using data from several censuses, a systematic analysis is made of age misreporting to discover which cohorts are really disproportionate in size. Model life tables are used with census data to estimate

adult mortality. Survey data is used to estimate child mortality. Fertility is estimated both as a residual and through the reverse survival of age group 0-9. Age group 0-4 was not used alone because it was found to be understated.

Gaisie (1969): Estimates are made for Ghana relevant to 1960. The author uses both census data and survey data on fertility and mortality. Vital rates are estimated in a variety of ways by combining these data. In the stable population method, various measures are used to identify the age distribution: (0-4)/(15-44), (5-14)/5+, (0-14)/(15-44), proportion under 15, under 20, under 30, ...

Krotki and Thakur (1971): Evidence of selective under-enumeration in Nepal (1961) is first considered through an analysis of sex ratios, age ratios, census survival rates, and the single-year age distribution. After slight adjustments for misreporting at age 5-9, it is found that confidence can be placed on the proportion (5-9)/25+. The age pyramid is then "doctored" on the basis of this proportion. The under-enumeration, all below age 25, was found to be 4.6%. The vital rates estimated on the basis of the adjusted population are claimed to be superior: they require less heroic assumptions in regard to under-enumeration, they show more consistency with rates derived by other means, and the rates obtained using various proportions in the adjusted population show less variability.

Romaniuk and Piché (1971): Official birth rates for Indians and Eskimos in Canada for the period 1900 to 1960 were found to be unreliable. Stable population estimates were derived using the proportion at ages 0-4 and at ages 0-14. The former proportion was generally preferred

because of slightly higher under-estimation in age group 5-14. The 0-4 proportion is also more sensitive to recent changes in fertility. The age distribution is accepted without alteration.

It is the author's intention to undertake, in a subsequent project, an analysis of the effects on final estimates of the various assumptions in regard to misreporting versus under-reporting in some of the above studies.

2.8 Outline of Procedures Chosen

By way of conclusion to this chapter, the major steps in arriving at the desired estimates are outlined below. This also establishes a type of summary of the suggestions put forth in the above discussions.

(a). Establish the rate of natural increase. The rate of growth as calculated from the inter-census change must be adjusted for two possible errors:

i. Effects of migration: we must attempt to estimate migration (including its age- and sex-selectivity) so that the population can be artificially closed;

ii. Effects of differential under-enumeration between the two censuses: any evidence of such a differential should be taken into account in estimating the actual rate of natural growth.

(b). Adjust the age-sex distribution. Apart from distortions due to migration, those that may be due to misreporting and/or to selective omissions must be considered. This would be based partly on cultural and social reasons for the possible misreporting and/or under-enumeration but especially on an analysis of the internal consistency of the enumerated age distribution through the following measures:

i. Masculinity ratios of the various age groups: this ratio (males per one hundred females) should normally be slightly over 100 in the young childhood ages, then remain steady around 100, to later move somewhat below this figure for the older age groups.

ii. Age ratios for each sex: these ratios (proportion which a given five-year age group bears to the average of its two neighboring age groups) should normally be near unity throughout the population.

iii. Census survival rates of the various age groups for each sex: these rates (proportion of a given age group surviving to the appropriate group in the following census) should all be less than unity, rising to a peak somewhere between ages 5 and 14 and then declining with age at an increasing pace.

iv. Single-year age distribution: distortions in the regularity of this distribution can be used as evidence of age heaping and sometimes of direction of the age shift.

Distortions in the above measures must be accounted for by misreporting and/or selective under-enumeration. Adjustments are made for under-enumeration when it is hardly possible that the error involved is due to misreporting. An ogive (proportion to a certain age) in which one can have confidence is then chosen so that the cumulation takes care of misreporting.

(c). Use this adjusted growth rate and age distribution as the basis for estimating vital rates:

i. Census survival method: in this procedure, the age distribution is adjusted only for differential under-enumeration (including that which would have affected given age groups more in one of the two censuses used). Other misreporting and under-enumeration would assume to cancel out.

ii. Stable population method: adjusted proportions at different ages in the later census and growth rate determine the choice of a model stable population whose parameters are assumed to be those of the given population.

iii. Quasi-stable adjustments: changes in the rate of growth over a given time period is used as evidence of declining mortality. Adjustments are then made for effects of this change on estimated rates.

The methods outlined in sections (a) and (b) above will be used in Chapter 3, while those of section (c) will be applied in Chapter 4.

CHAPTER 3

PRESENTATION AND ADJUSTMENT OF DATA

Though the estimates that are to be derived for the Moroccan population simply require that we have as data the rate of growth and some measure of the age distribution, it is immediately evident that establishing these two parameters is in itself problematic. Bourgeois-Pichat (1958), who was probably the first demographer to make use of these stable population methods in estimating vital rates, warns that they should never be used mechanically. Any brief glance at the graphs and tables presented in this chapter is sufficient to indicate the inadequacy and distortion in the data that are to be used.

We will therefore proceed to make adjustments first to the growth rate (for migration and differential under-enumeration), then to the age distribution (for omissions and misreporting). In order to gain insight into the data, a brief history of Moroccan censuses will first be given. Comparisons will also be made with Algerian and Tunisian age distributions, and the various explanations that have been offered to take account of the distortions will be reviewed.

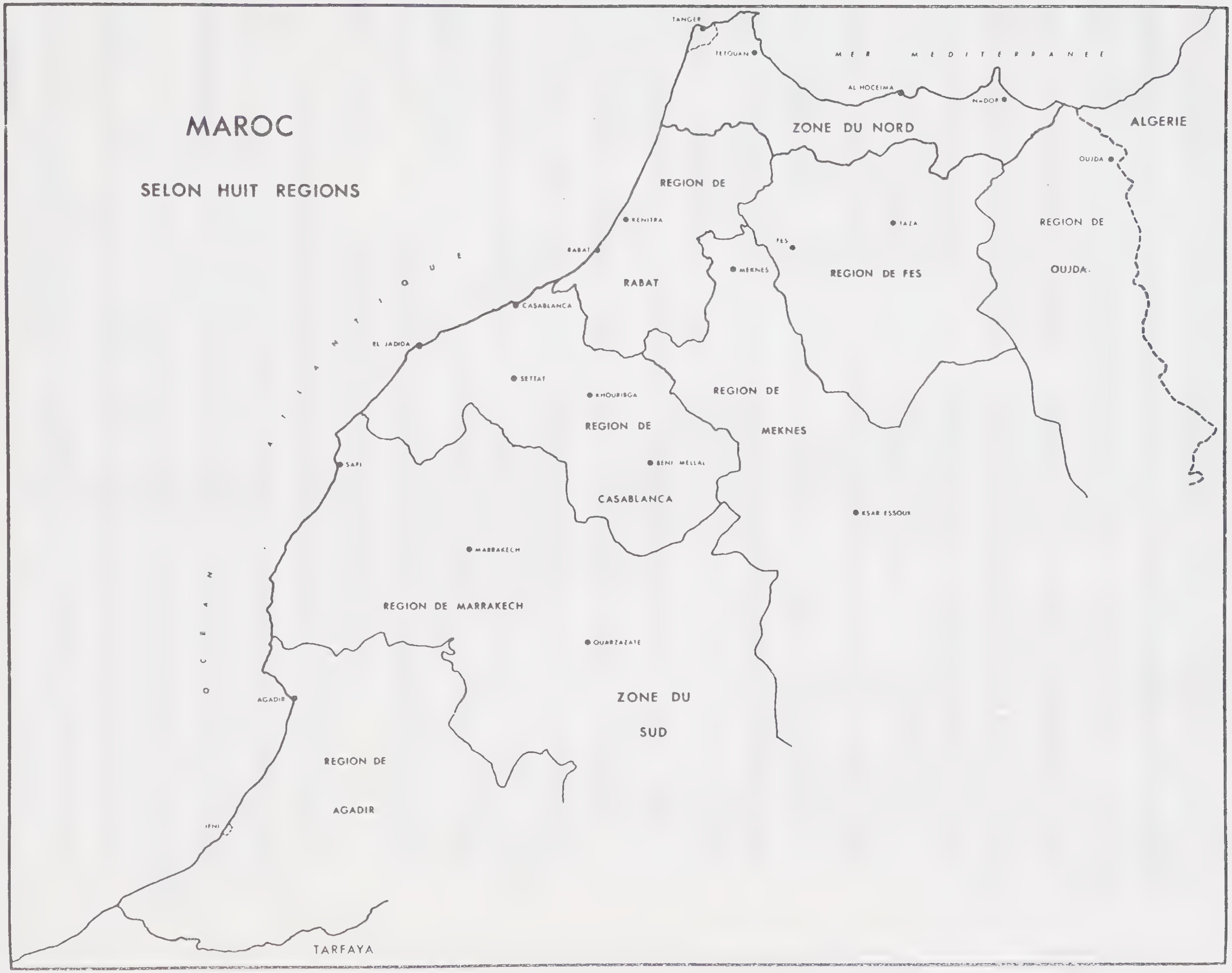
3.1 Moroccan Censuses, 1921 to 1971

Though the 1960 census was the first operation of this kind undertaken simultaneously for the whole of Morocco and for all populations living therein, there are a number of earlier enumerations dating back to 1921. Before the country obtained its independence in 1956, it was divided into the French (South) and Spanish (North) Protectorates.

These regions will hereafter be called South Zone and North Zone, respectively (Figure 1). Three other divisions within the country must also be kept in mind. Ifni, a small corner on the south edge of Agadir, was not integrated into Morocco until after 1960 and it will therefore be left out of this analysis. Tanger, to the north opposite Gibraltar, was administered until 1956 as an international port. Tarfaya, which stretches below Agadir to the Spanish Sahara, is mostly a desert area which was also administered by Spain and thus the estimates are sometimes included with those of the North Zone. Some estimates, but no enumerations, are available for these three areas during the colonial period.

For the South Zone, a total of six enumerations were made before independence. The three for 1921, 1926, and 1931 covered only the regions that had then been conquered ("regions contrôlées") though estimates have been made for the other regions. In 1921, the rural Muslem population was simply estimated on the basis of the number of dwellings. The results of this first operation are claimed to be of little value. The 1926 enumeration initiated the division of the Muslem population into three age categories (children, adults, old people) but no information on sex was obtained. In 1931, the sex distinction was added, for the Muslem population, to that of the three age groups. At the fourth enumeration in 1936, the whole South Zone was included ("pacification achevée"). The Muslems were still enumerated by means of lists provided by local authorities and again by the three large age groups. However, as regards the total count, this enumeration is definitely superior to the previous ones. Noin (1970: I: 30-32) even claims that it is superior to the 1951-52 results, while Benyoussef (1967: 44) regards the 1936 and 1951-52

FIGURE 1. MAP OF MOROCCO BY ADMINISTRATIVE REGIONS



censuses to be about equal in quality but superior to all other pre-independence counts. The enumeration of 1947 is generally disregarded. The fact is that it enumerated more Morocco Muslems and Morocco Israelites than did the 1951-52 count. It was based on lists established for the distribution of ration tickets and it is thus expected to have over-estimated the population. This over-estimate would affect particularly women and children. The masculinity ratio obtained (95.1), which is lower than at any other census, tends to support this assumption. The next census took place in 1951-52 and involved the first real individual enumeration. It was carried out in two stages. The Foreigners, Morocco Israelites, and those Muslems who were living in European quarters were enumerated relevant to April 15, 1951. The remainder of the Muslem population was subsequently enumerated relevant to April-May, 1952. A certain sample (about 1/14) of the Morocco Muslem population was asked to declare age, thus providing the first age distribution for this population. However, as Noin (1970: I: 32) notes, this census took place during the period of struggles that preceded the end of the Protectorate. He thus suspects an under-enumeration especially of men in urban areas and of various tribes in certain rural areas.

The author did not locate the original publications of census results for the North Zone. Here we seemingly have four censuses before independence: 1930, 1935, 1940, and 1950. Noin (1970) claims that the ones of 1935 and 1950 are much more reliable than the others. The latter (relevant to December 31, 1950) established the age distribution of the population. This distribution is reputed to be the best ever obtained in Morocco.

TABLE 1. POPULATION OF MOROCCO BY ETHNICITY FROM CENSUSES AND ESTIMATES, 1921 TO 1971.

	ALL ETHNIC GROUPS	MOROCCO MUSLEMS	MOROCCO ISRAELITES	FOREIGNERS
SOUTH ZONE (FRENCH)				
1921	4,333,780	4,161,800[a]	91,315	80,665
1926	4,902,164	4,681,900[a]	115,552	104,712
1931	5,364,766	5,067,700[a]	124,585	172,481
1936	6,245,236	5,880,700	161,942	202,594
1947	8,617,387	8,088,551	203,839	324,997
1951-52	7,998,304	7,442,110	199,156	357,038
NORTH ZONE AND TARFAYA (SPANISH)				
1930	750,000	690,000	12,000	48,000
1940	1,003,954	926,067	14,734	63,153
1950	1,025,117	932,086	7,872	85,159
TANGER				
1941	102,306	72,670	7,102	22,534
1952	172,000	115,000	15,000	42,000
WHOLE COUNTRY				
1960	11,626,232	11,067,929	162,420	395,883
1971	15,379,259	15,236,153	31,119	111,987

[a]This includes estimates for the non-conquered regions:
1921: 790,000
1926: 665,000
1931: 476,100

Sources: Maroc, Service des Statistiques, 1947: II: 2-3;
Maroc, Service Central des Statistiques (S.C.S.) 1952: III: XVIII.
Maroc, S.C.S., 1965: I: 8-9.
Le Petit Marocain (le 2 novembre, 1971) for 1971 data.

Two censuses have been taken since independence. The one of June 18, 1960, covered the whole country including Tanger and Tarfaya but still excluding Ifni. In rural areas, a full count was made; and, in one-tenth of the douars (administrative districts with ten to five-hundred households), additional information was obtained on each individual. In urban areas, this information was gathered for the entire population. The operation was in all likelihood superior to the previous censuses; more will be said about this later. The last census was held in 1971 (relevant to July 20) but at the time of this writing only a few gross totals are available to this author and these will generally be neglected. For a descriptive evaluation of this 1971 census operation, see Beaujot and Elamrani-Jamal (1972).

3.2 Migration

Movement across international boundaries distorts the rate of natural growth as calculated from inter-census change. It is therefore necessary to control for this factor. Migration in Morocco has been selective by ethnicity and thus the various groups will be considered separately.

All indications are that migration of Muslems during the reference period (1950-1960) is rather negligible. There are presently large numbers of Moroccan workers going to various European countries (especially to France) but the statistics available would show that this trend has gained considerable proportions only since 1960.[5] The best source of

[5]The Ministère du Travail et de la Formation Professionnalle (Royaume du Maroc) registered only 1,245 departures of Moroccan workers in 1960, while in 1970 there were over 31,000. French sources [Institut National de Statistiques et d'Etudes Economiques (INSEE), 1966: 90] registered only 3,300 permanent entries of workers during the 1950-60 decade in comparison with 56,000 for the years 1961-65. The French

information on the migration of Muslems is the French censuses. These establish the total of Moroccans in France as 10,700 in 1954 and 33,300 in 1962.[6] International Migration Digest (1965) indicates that 80% of Moroccan workers emigrating to Europe go to France. We could thus propose a figure in the order of 25,000 as the net loss to Europe in 1952-1960. A few other migratory movements should be considered. Muslems are requested by their religion to make a pilgrimage to Mecca. Prothero (1965) suggests that some pilgrims return home only twenty or thirty years after having set out. He presents a map which shows 7,289 Moroccans at Mecca for an undefined year. It could probably be assumed, however, that the number of pilgrims missed by the 1960 census would not be very different from that missed by the 1950-52 count. This movement would, therefore, not greatly affect the inter-census growth rate. There are also certain, though rather limited, nomadic movements which cross the international boundaries with Algeria and the Spanish Sahara.[7] But again, besides being completely unable to set a figure to this movement, it would tend to affect both censuses somewhat equally. There is also the possibility of migration to other African countries but no information

---

census of 1968 would confirm this new trend by placing the total number of Moroccans in France at 88,200 [with 10,700 in 1954 and 33,300 in 1961 (Prevost, 1969: 14)]. The figures for 1969 and 1970 are of the order of 143,000 and 170,000, respectively.

[6]Devillars (1954) is a valuable source of information on emigration of Muslems to France. Using official statistics (1949) and a survey of clandestine arrivals at St. Etienne, he suggests a total of 18,000 Moroccans in France in 1951. This, however, is of little assistance here since the study was not repeated in 1960. There is always the possibility that clandestine emigration is continuing (see Opinion, 1971). For the earlier period, see Ray (1938).

[7]The census publication (Maroc, S.C.S., 1965: I: 35) refers to this nomadic movement across borders as minimal. For qualitative references, see Ghansah (1969), Paskoff (1957), and Prothero (1965: 115-19).

regarding this was located. It was decided to set the net loss of Muslems through migration during the 1950-52 to 1960 period at 30,000. This is somewhat in agreement with Moroccan sources which place the net loss (departures over arrivals) of Muslems at 19,800 for the period 1956 to 1960.[8]

The emigration of Israelites is of larger proportions, especially in relation to the total size of this population (222,000 in 1950-52 and 162,000 in 1960). An analysis of the extent of this loss is presented along with the results of the 1960 census (Maroc, S.C.S., 1965: I: 33). By comparing the projection ($e_0 = 55$) of the 1952 population with the age distribution of 1960, they establish a loss of some 80,500 who had been enumerated in 1950-52 plus some 27,000 who would have been born since for a total of 107,500.[9] This conforms somewhat with Israeli sources (Central Bureau of Statistics (C.B.S.), 1966: 46) since the number of Jews born in Morocco, Algeria, and Tunisia who were in Israel in 1960 is estimated at 158,773. Unfortunately, the immigrants from these three countries are not separated in the Statistical Abstract of Israel so that a direct comparison is not possible.

The foreign population is still further from being closed, since both in- and out-migration are occurring.[10] These foreigners include (in 1960) 54% French, 8% Spanish, 29% Algerians, 3% Italians,

---

[8]These sources (Maroc, S.C.S, Annuaire. . .) are, by their own account, inadequate until 1956 because they missed many departures toward Algeria in the Oujda region.

[9]The actual number of emigrants would be 94,000 with the other 13,500 being births to migrants after the latter's departure.

[10]According to the census publication, the important emigration would have started around 1956 but there would be an immigration of some 53,000 Algerian refugees before 1960.

and 6% others. The total is 484,000 in 1950-52 and 395,000 in 1960. An analysis by projection would suggest a net loss of 93,000 who had been counted in 1950-51 plus some 31,800 children born since for a total of 125,400.[11] This compares somewhat with the statistics of repatriations to France, the estimates of which vary between 125,000 and 170,000 for 1955 to 1960 (France, INSEE, 1969: 117).

This analysis of migration shows that only the Morocco Muslem population is relatively closed.[12] Thus the major part of the subsequent analysis is based on only this group. Immigration, by definition, cannot affect this group since, for example, Algerian refugees were classified as Foreigners and not as Morocco Muslems. These considerations regarding migration do, however, have some effect on the calculated growth rates (Table 2) and age distributions (Tables 3 and 4) that will be used as the basis for the estimates.

---

[11]The total for 1951 in the South was first reduced by 2% to be able to add it to the North totals. A projection with level 19 of the U.N. (1967) Population Study Number 42 ($e_o = 65$) suggests a loss of 93,500. If we impose the same proportion for ages (0-9)/(10-19), we need to add another 31,800 at ages 0-9 in 1960. The actual migrants would be 109,400 with the remaining 15,900 being made up of births to migrants once these had left.

[12]The estimates presented here are in relative conformity with those presented in the U.N. Demographic Yearbooks. Our calculations indicate a total of 30,000 + 94,000 + 109,000 = 233,000 net loss through migration. The Demographic Yearbooks tabulate 265,000 long-term emigrants and 85,000 long-term immigrants in the 1955 to 1960 period for a net loss of 180,000. On the other hand, the net difference between arrivals and departures for the same period would indicate a loss of 260,000.

TABLE 2. POPULATION OF MOROCCO AND ANNUAL GROWTH RATES 1952 TO 1960, GROSS FIGURES AND ADJUSTMENTS FOR MIGRATION

		1960		ANNUAL PERCENTAGE OF GROWTH	
	1952[a]	CENSUS POPULATION	CLOSED POPULATION[b]	FROM GROSS FIGURES	AFTER ADJUSTMENTS FOR MIGRATION
Muslems	8,530,660	11,067,930	11,097,930	3.2	3.3
Israelites	212,830	162,420	269,920	-3.3	3.0
Foreigners	489,480	395,880	521,300	-2.6	0.8
TOTAL	9,232,970	11,626,230	11,889,150	2.9	3.1

[a]In order to move all populations to 1952, certain adjustments were made to the data from 1950 (North Zone) and from 1951 (Israelites and Foreigners). For the Muslems, the 1950 totals (North) were increased by 2.2% per year. For the Israelites, the totals from the North (1950) and from the South (1951) were increased by 2.0% per year. For the Foreigners, the totals of the North (1950) and of the South (1951) were increased by 1.0% per year.

[b]There were 30,000 Muslems; 107,500 Israelites; and 125,400 Foreigners added to compensate for migration (see text).

Source of base data: Maroc, S.C.S., 1965: I: 8-9.

TABLE 3. AGE DISTRIBUTIONS WITH ADJUSTMENTS FOR MIGRATION, MOROCCO MUSLEMS AND TOTAL POPULATION, 1960

	MOROCCO MUSLEMS			
	CENSUS DATA		AFTER ADJUSTMENTS FOR MIGRATION	
	MALES	FEMALES	MALES	FEMALES
0-4	1,037,964	1,087,249	1,038,400	1,087,718
5-9	919,287	883,445	919,660	883,795
10-14	584,929	437,440	585,201	437,635
15-19	349,308	327,845	349,632	328,117
20-24	392,114	479,366	395,123	479,666
25-29	417,119	499,642	421,211	500,004
30-34	371,062	428,329	375,711	428,687
35-39	314,223	288,201	317,178	288,498
40-44	274,216	293,147	277,026	293,510
45-49	176,304	142,298	178,406	142,513
50-54	190,470	204,901	192,999	205,259
55-59	96,672	64,100	96,995	64,272

TABLE 3. Continued.

	MOROCCO MUSLEMS			
	CENSUS DATA		AFTER ADJUSTMENTS FOR MIGRATION	
	MALES	FEMALES	MALES	FEMALES
60-64	160,468	184,954	161,032	185,392
65+	242,324	197,530	243,048	198,219
Total	5,526,460	5,518,447	5,551,622	5,523,285
N.D.[a]	12,072	10,950	12,072	10,950
TOTAL	5,538,532	5,529,397	5,563,694	5,534,235

	TOTAL POPULATION			
	CENSUS DATA		AFTER ADJUSTMENTS FOR MIGRATION	
	MALES	FEMALES	MALES	FEMALES
0-4	1,073,163	1,121,647	1,090,512	1,137,944
5-9	955,045	917,805	971,276	932,085
10-14	616,109	466,611	628,753	479,497
15-19	370,937	351,383	383,803	361,522
20-24	406,634	500,892	422,145	507,676
25-29	434,767	521,978	445,025	526,554
30-34	390,269	450,119	409,615	455,380
35-39	332,918	308,043	346,230	315,752
40-44	289,755	309,381	300,007	314,863
45-49	190,561	156,702	199,881	162,659
50-54	204,069	218,538	211,971	223,539
55-59	107,164	73,759	111,895	77,890
60-64	169,486	194,575	173,041	197,186
65+	255,283	213,648	259,335	217,384
Total	5,796,161	5,805,081	5,953,489	5,910,651
N.D.[a]	13,011	11,979	13,011	11,979
TOTAL	5,809,172	5,817,060	5,966,500	5,922,630

[a]N.D. = Age not declared.

Note: In establishing the age distribution of the migrant population, the following procedures were used. The 30,000 Muslems were divided into age groups according to the masculinity ratio (520) of Moroccans in France in 1962 and according to the age distribution of Foreigners in France (INSEE, 1967). (This latter assumption is highly questionable but it provides the only viable alternative given the available data.) The 107,500 migrant Israelites were established on the basis of projections (Maroc, S.C.S., 1965: I: 33); and thus the age distribution of the projected population minus the age distribution of the enumerated population gives the age distribution of the emigrant population. The same procedure was used for the 125,400 Foreigners.

Source of base data: Maroc, S.C.S., 1965: I: 104-05.

TABLE 4. ESTIMATED AGE DISTRIBUTION, MOROCCO MUSLEMS, 1950

	MALES	FEMALES
0-4	693,935	723,751
5-9	607,069	559,815
10-14	459,430	332,190
15-19	295,936	294,940
20-24	239,065	347,560
25-29	275,228	392,495
30-34	304,854	385,797
35-39	253,490	220,232
40-44	238,185	258,730
45-49	148,903	119,221
50-54	173,392	186,773
55-59	75,471	56,361
60-64	125,647	133,839
65+	160,151	124,463
TOTAL	4,050,756	4,136,167

Procedure used:

1. Population of the South in 1952 (Maroc, S.C.S., 1965: I: 36) was reduced uniformly by 4%.
2. Population of the North in 1950 (Maroc, S.C.S., 1965: I: 37) was added.
3. The estimates of total population for 1950 of Tanger and Tarfaya (Maroc, S.C.S., 1965: I: 8, 37) were added, assuming the same age structure as the combination of North and South Zones.

3.3 Differential Under-enumeration and Final Estimates of Natural Growth 1952-1960

Only the Morocco Muslem population will be considered here.[13] It was noted in the first section of this chapter that there are various reasons to expect a superiority of 1960 census data over that of 1950-52. The comprehensive studies of Benyoussef (1967) and Noin (1970) are in agreement on this point. But the difficulty is that of fixing a figure to the differential. The gross data for 1950-52 and 1960 would indicate

[13] Muslems constituted 91.9% of the Population of Morocco in 1950-52 and 95.2% in 1960.

that, after proportional adjustments for the various regions, the rate of growth of Muslems would be in the order of 3.25% per year (Table 5).

TABLE 5. POPULATION OF MOROCCO AND ANNUAL GROWTH RATES, 1950-1971

	1950	1951	1952	1960	1971	ANNUAL GROWTH RATE
						1950-52 TO 1960
SOUTH ZONE						
Muslems			7,442,100	9,783,700		3.4
Israelites		199,160		151,290		-3.0
Foreigners		357,040		320,310		-1.3
NORTH ZONE						
Muslems	932,100			1,160,800		2.2
Israelites	7,870			4,880		-4.7
Foreigners	85,160			41,070		-7.0
TANGER						
Muslems			115,000	123,480		0.9
Israelites			15,000	6,250		-10.4
Foreigners			42,000	34,510		-2.4
AVERAGE WEIGHTED BY 1960 TOTALS						
Muslems						3.25
Israelites						-3.3
Foreigners						-2.0
WHOLE COUNTRY						1960 TO 1971
Muslems					15,236,153	2.9
Israelites					31,119	-13.9
Foreigners					111,987	-10.8

Note: No adjustments.

Sources of data: Maroc, S.C.S., 1965: I: 8;
Le Petit Marocain (le 2 novembre 1971).

However, a comparison with previous censuses (Table 6) casts doubts on this rate. It is unlikely that the growth would be lower in the periods

1936-1952 (South) and 1940-1950 (North) than in the previous inter-census periods. It is equally unlikely that the growth since 1950-52 would be so much higher than that of the 1936-40 to 1950-52 period. The 1950-52 enumeration would therefore seem to have been subjected to more omissions that that of 1960. As was noted earlier, the former census was held during the period of struggles that preceded the end of the Protectorate.

TABLE 6. MOROCCO MUSLEM POPULATION AND GROWTH RATES, 1921-1960

	POPULATION	ANNUAL GROWTH RATE[a]
SOUTH ZONE		
1921	4,161,800	---
1926	4,681,900	2.3
1931	5,067,700	1.6
1936	5,880,700	3.0
1952	7,442,100	1.5
1960	9,783,700	3.4
NORTH ZONE AND TARFAYA		
1930	690,000	---
1940	926,100	3.0
1950	932,100	0.1
1960	1,160,800	2.2

[a]Since previous census.

Note: No adjustments.

Source of data: Maroc, S.C.S., 1965: I: 8.

Additional information on differential under-enumeration can be obtained by comparing the two age distributions (Figure 2).[14] These superimposed pyramids are roughly similar but two sources of differences are evident: there are considerably fewer at ages 0-9 in 1950 and there

[14]For sources of data, see Table 3 (1960 Muslems After Adjustments for Migration) and Table 4.

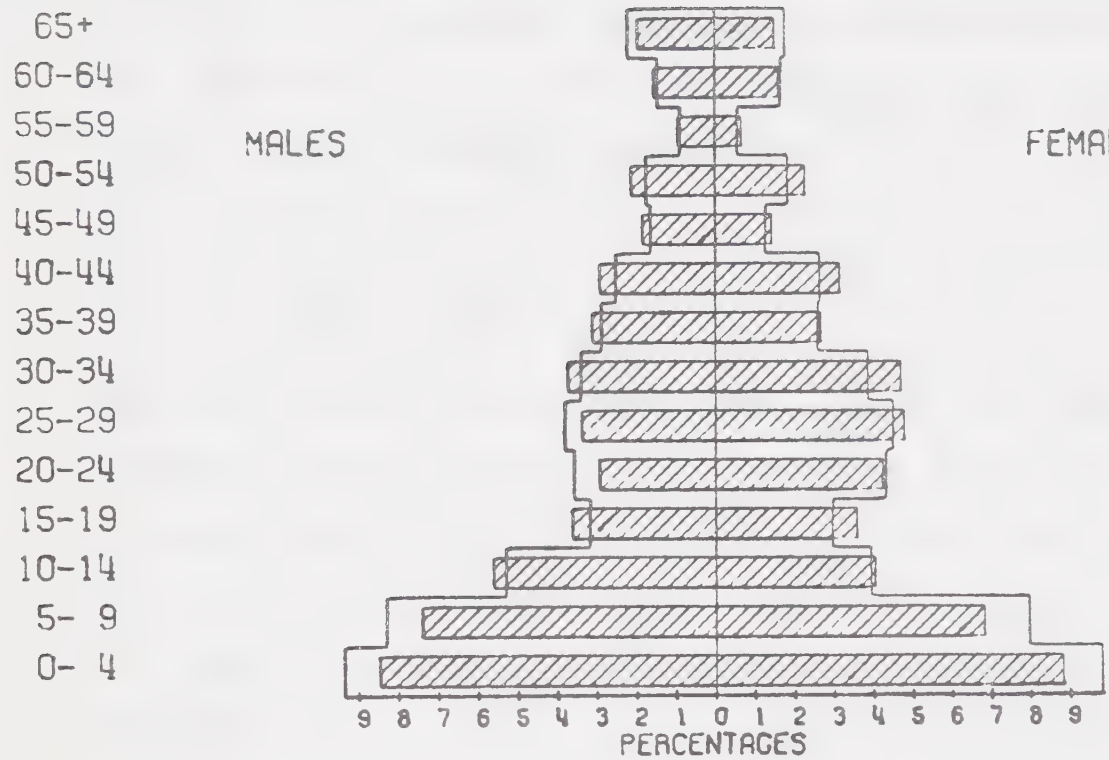


FIGURE 2. MOROCCO MUSLEMS

1950 AND 1960

POPULATION RESEARCH LABORATORY
UNIVERSITY OF ALBERTA

are fewer men in ages 20-29 in 1950. These differences will be taken up in the opposite order.

It could be expected that political turbulence would have more impact on the enumeration of the male sex. It is difficult to know what the sex ratio of a population like that of Morocco should be; some authors have argued for relatively strong female mortality. The masculinity ratios in the various censuses are as follows:[15]

1931:	101.9
1936:	101.4
1947:	95.1
1952:	98.4
1960:	100.2

Other than the ratio for 1947 (which probably indicates an over-estimate of females because of the use of ration tickets as the basis of the census count), the ratio for 1952 is the lowest. The masculinity ratios by age give evidence of a more predominant lack of males at ages 20-34 in 1950 (Figure 3). To bring the 1950 sex ratios for these ages in line with those of 1960, we need to add 135,900 men.[16] This brings the over-all masculinity ratio of 1950 to 101.2.

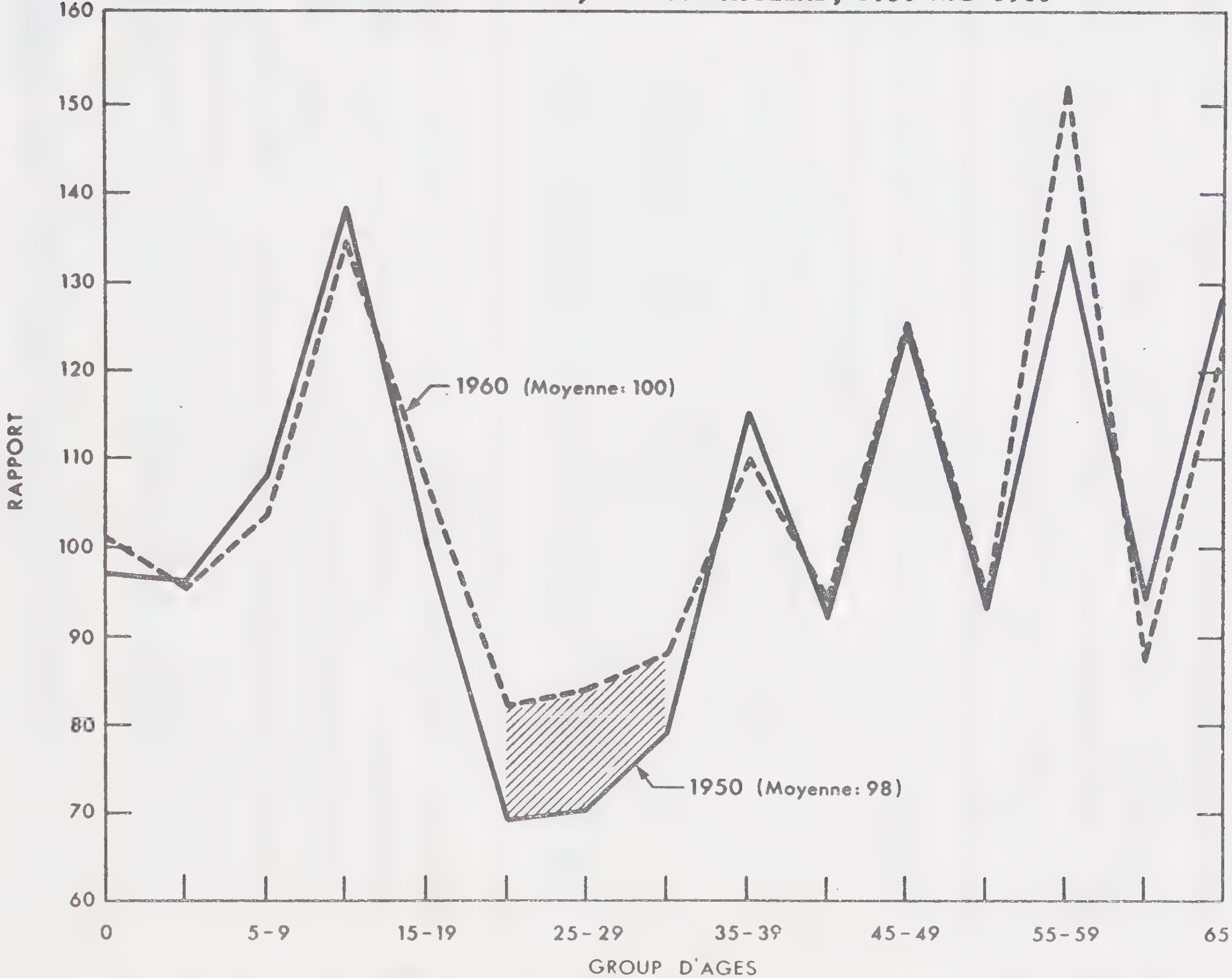
The divergence at ages 0-9 is more difficult to explain. The distribution by single years of age, which will be presented later (Figure 15), shows that the difference exists at almost each of these ages of each sex and especially at age zero. Both census publications (Maroc, S.C.S., 1952: I: XXVI; 1965: I: 45) suspect that the very young have been under-enumerated. However, indications would be that this was worse

---

[15]Sources of data: Maroc, Service des Statistiques (1947: II: 2-3); Maroc, S.C.S. (1952: III: XXII); Maroc, S.C.S. (1965: I: 105).

[16]Females 1950 x Masculinity ratio of 1960 = Males 1950. This 135,900 is the total of 47,242 at 20-24; 55,420 at 25-29; and 33,270 at 30-34.

FIGURE 3. MASCULINITY RATIOS, MOROCCO MUSLEMS, 1950 AND 1960



Sources of data: See Table 3 (1960 adjusted for migration) and Table 4.

in 1950-52. Part of the difference could be explained by a decline in infant mortality; but a decline in the order of 150 per 1,000 would be necessary to explain the whole difference.[17] It could also be that fertility was reduced in 1950-52 due to political problems. A difference of 4.0 per 1,000 in the crude birth rate would explain the average proportionate differences in ages 0-9 (or a difference of 6.5 per 1,000 would explain the divergence at age zero).[18] Any estimate within this range can be little more than a guess. If we allow for a decline of 30 per 1,000 in the infant mortality rate, there remains a difference of 3.0% in the proportion at ages 0-9. Three hypotheses will be retained to cover the range of possibilities:

(a). All the difference is due to fertility change: no differential under-enumeration at 0-9 in 1950-52;

(b). Half the difference is due to fertility change: differential under-enumeration of 1.5% or of 122,800 children in 1950-52;

(c). None of the difference is due to fertility: differential under-enumeration of 3.0% or of 245,600 children in 1950-52.

As noted earlier (section 3.1), it is suspected that part of the relative under-enumeration of 1950-52 involved whole areas. This type of omission could not be picked up by differences in the age distributions. To isolate the regions that may have been more affected, the rates of growth were calculated according to seven regions (see map,

---

[17] The average difference in proportions for ages 0-9 is 0.4%; applied to age zero, the implied difference in infant mortality is calculated as follows:

$$\frac{\text{change in the proportion aged zero x total population}}{\text{proportion aged zero x total population}} \times 1{,}000 \text{ or}$$

$$\frac{.004 \times 8{,}187{,}000}{.026 \times 8{,}187{,}000} \times 1{,}000 = 154.$$

[18] $$\frac{.004 \times 8{,}187{,}000}{8{,}187{,}000} \times 1{,}000 = 4.0.$$

Figure 1) that can be isolated for the censuses 1936 through 1971 (Table 7). In each region, the 1936-52 growth is considerably lower than the 1936-60 growth, while the 1950-52 to 1960 rates are very high. The region of Fez seems to indicate an excessive under-enumeration in 1952: its 1952-1960 growth is equal to the average for the country while the 1936-1952 growth is zero. Since its population increased over the whole period 1936-1960, it would be difficult to accept that all this increase occurred after 1952. Another factor would isolate this region as problematic: as the pre-Colonial capital, it has always been an important center of political activity. Projecting from the various regional growth rates, we could suggest an under-enumeration of some 120,000 for the region of Fez.[19] Since such a strong under-enumeration could have occurred in one region, we could propose an even larger under-enumeration for the whole of the country.

As a conclusion to this section, the various suggested adjustments for under-enumeration are put forth in the form of three hypotheses (Table 8). The basis for these hypotheses is little more than a calculated guess. The main idea is to span the range of possible growth rates. The assumptions are as follows:

Hypothesis 1: No differential under-enumeration between the two censuses;

Hypothesis 2: Medium range of differential under-enumeration affecting the 1950-52 census;

Hypothesis 3: Strong differential under-enumeration affecting the 1950-52 census.

---

[19]Since the growth rate for 1936-1960 is half of the rate for the South Zone, the rate of 0.75% per year (half the 1936-1952 rate of the South Zone) was used to project the 1936 population to 1952. This brings the total up to 1,080,000 rather than the enumerated 958,950.

TABLE 7. ANNUAL GROWTH RATES BY REGION AND SEX, 1936-1971

	MOROCCO MUSLEMS			ALL ETHNIC GROUPS
	1936-1952	1952-1960	1936-1960	1960-1971
CASABLANCA				
Males	1.6	3.8	2.3	3.0
Females	1.8	3.5	2.4	
FEZ				
Males	-0.1	3.4	1.0	2.3
Females	0.0	3.2	1.0	
MARRAKECH AND AGADIR				
Males	0.9	2.8	1.6	2.1
Females	1.3	2.4	1.7	
MEKNES				
Males	2.2	3.9	2.8	2.4
Females	2.5	3.6	2.9	
OUJDA				
Males	2.7	4.8	3.4	1.7
Females	2.6	5.3	3.5	
RABAT				
Males	3.1	4.3	3.5	3.3
Females	3.4	4.0	3.5	
TOTAL SOUTH ZONE				
Males	1.4	3.5	2.1	2.6
Females	1.6	3.3	2.1	
NORTH ZONE	1940-1950	1950-1960	1940-1960	
Males	-0.1	2.4	1.2	2.2
Females	0.1	2.0	1.0	

Note: 1. This excludes Tanger and Tarfaya throughout.

2. The regions were checked for changes with the use of administrative maps relevant to the various dates. The only change (other than the later sub-division of regions) is in regard to the "Territoire du Dra" which in 1936 spanned the southern edges of the regions of Agadir, Marrakech, and Meknes to the north of the Algerian border. The small population (78,017) of this region was arbitrarily divided equally among the three regions involved.

3. No adjustments for migration.

Source of data: Maroc, Service du Travail et des Questions Sociales (1936: 2-3);
Maroc, S.C.S. (1952: III: 10-11);
Maroc, S.C.S. (1965: I: 62);
<u>Le Petit Marocain</u> (le 2 novembre 1971).

TABLE 8. POPULATION OF MOROCCO IN MAY, 1952, AND ANNUAL GROWTH RATES 1952-1960, ACCORDING TO THREE HYPOTHESES OF DIFFERENTIAL UNDER-ENUMERATION

	HYPOTHESIS 1	HYPOTHESIS 2	HYPOTHESIS 3
MOROCCO MUSLEMS			
Enumerated in 1952	8,530,660	8,530,660	8,530,660
Adjustments for under-enumeration			
Males 20-34	0	135,900	135,900
Children 0-9	0	122,800	245,600
Fez and other regions	0	120,000	180,000
NEW TOTAL FOR 1952	8,530,660	8,909,360	9,092,160
Implied under-enumeration in 1952	0.0%	4.3%	6.2%
Annual Growth 1952-1960	3.4%	2.8%	2.4%
ALL ETHNIC GROUPS IN 1960			
Annual Growth 1952-1960	3.3%	2.7%	2.3%

Note:

1. The 1952 population has been adjusted for differences in census dates (see Table 2, footnote 'a').
2. The 1960 population that was used (11,097,930 Muslems and 11,889,150 for all ethnic groups) had been adjusted for migration by adding 30,000 Muslems; 107,500 Israelites; and 125,400 Foreigners. See Table 2.
3. The growth rates for the total population were calculated by weighting according to the 1960 estimates for the three ethnic groups.

Source of base data: Maroc, S.C.S., 1965: I: 8.

The first hypothesis is only given by way of comparison since, on the whole, the considerations presented give evidence of at least some differential under-enumeration. After these adjustments for migration and for differential omissions, the three hypotheses would suggest a natural growth of 3.4, 2.8, and 2.4, respectively for Muslems and of 3.3, 2.7, and 2.3 for the total population.

3.4 The Age Distribution

Now that the growth rate has been established, or at least the

probably range thereof, the next step is to make the necessary adjustments to the age distribution. The age schedule of particular interest here is that of the Muslems in 1960. However, other relevant pyramids will be presented for the sake of comparison. The main analysis of the distortions in the age distribution will be made through the study of its internal consistency (sections 3.6 to 3.9) after having considered the possible explanations of the irregularities (section 3.5).

Eight age distributions are presented for consideration (Figures 4 to 11): Morocco Muslems in each zone in 1960,[20] also in 1952 (South) and 1950 (North),[21] the sample of the 1961-63 Moroccan Multiple-Purpose Survey,[22] the sample of the 1959-60 Moroccan Consumer Survey,[23] the 1966 censuses of Tunisia[24] and of Algeria.[25]

As a means of testing the accuracy of census age distributions, a United Nations publication (1955: Population Bulletin Number 2: 59-79) suggests the use of certain test scores. These, as calculated for some of the relevant age distributions, are presented in Table 9. We note immediately that the Moroccan age distributions show many more distortions than do those of Algeria and Tunisia. The Moroccan irregularities are also outside the range of the hundred-odd scores tabulated in the

---

[20]This excludes Tanger and Tarfaya. No adjustments for migration. Source: Maroc, S.C.S., 1965: I: 105, 133, 148, 154, 155, 157.

[21]Source: Maroc, S.C.S., 1965: I: 36, 37.

[22]Source: Maroc, S.C.S., 1964: 28. Combination of rural (63,506) and urban (31,595) samples.

[23]Source: Maroc, S.C.S., 1961: 61. Sample of 1,955 urban and 2,370 rural households.

[24]Source: U.N., <u>Demographic Yearbook</u>, 1969: 160. Total population of 4,533,351.

[25]Source: U.N., <u>Demographic Yearbook</u>, 1969: 152. Total population of 12,075,249.

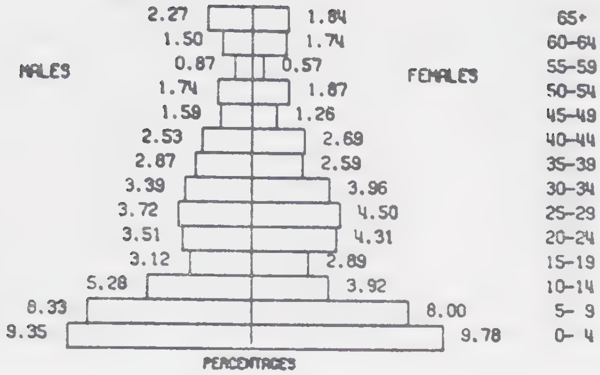


FIGURE 4. MOROCCO MUSLEMS 1960

SOUTH ZONE

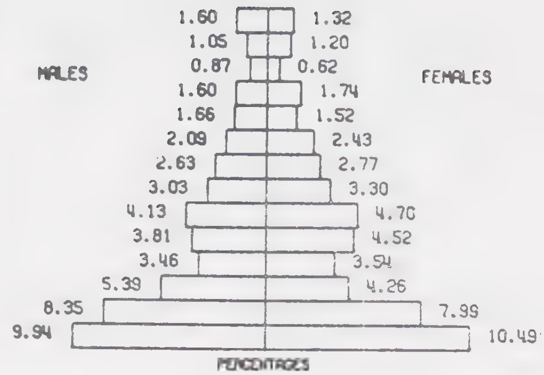


FIGURE 5. MOROCCO MUSLEMS 1960

NORTH ZONE

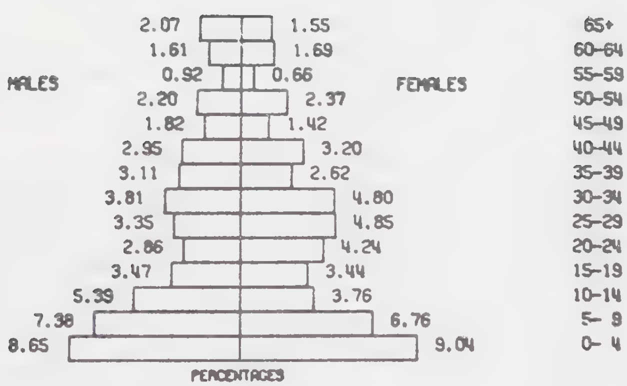


FIGURE 6. MOROCCO MUSLEMS 1952

SOUTH ZONE

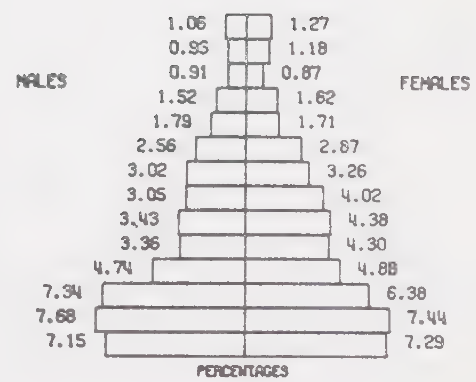
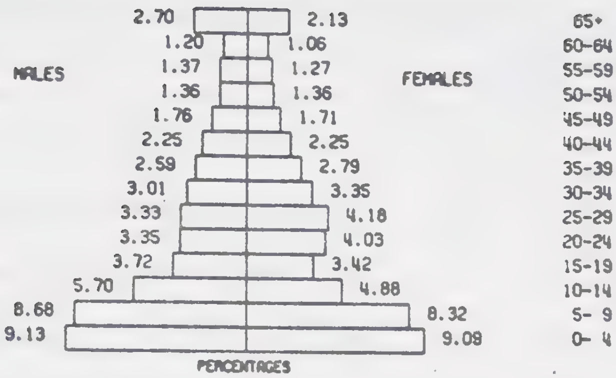


FIGURE 7. MOROCCO MUSLEMS 1950

NORTH ZONE



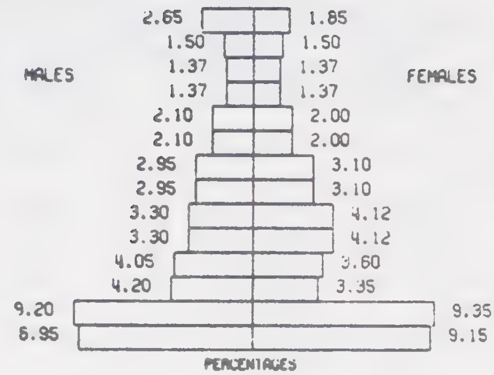
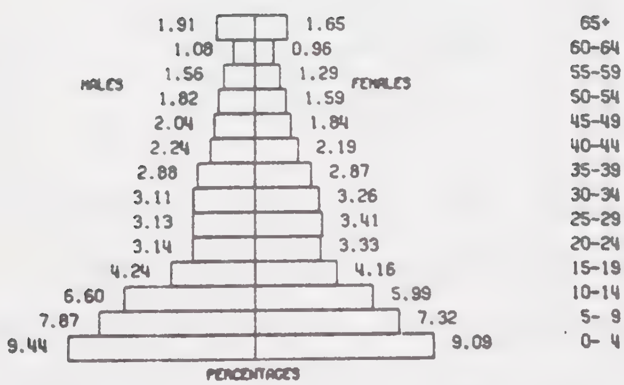


FIGURE 8. MOROCCO 1961-63

MULTIPLE-PURPOSE SURVEY SAMPLE

FIGURE 9. MOROCCO 1959-60

CONSUMER SURVEY



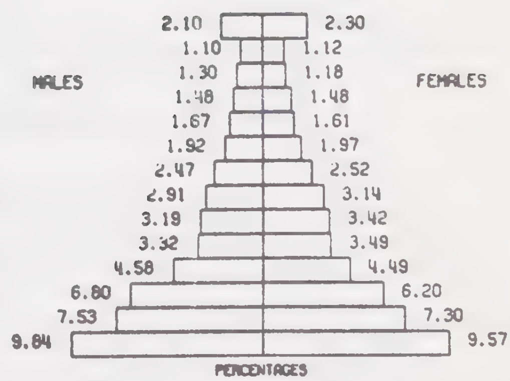


FIGURE 10. TUNISIA 1966

CENSUS

FIGURE 11. ALGERIA 1966

CENSUS

TABLE 9. TEST SCORES FOR ACCURACY OF VARIOUS AGE DISTRIBUTIONS

	SEX RATIO SCORE	AGE RATIO SCORE		JOINT SCORE
		MALE	FEMALE	
MOROCCO MUSLEMS 1950	27.3	17.5	36.0	135.4
MOROCCO MUSLEMS 1960	26.3	16.0	34.0	128.9
MUSLEMS, NORTH ZONE 1950	11.5	11.3	13.0	58.8
MUSLEMS, NORTH ZONE 1960	19.6	13.8	23.5	95.9
TUNISIA 1966	5.3	6.0	4.8	26.7
ALGERIA MUSLEMS 1954	12.8	10.5	20.5	69.4
ALGERIA 1966	5.2	5.8	6.5	27.9

Note: Sex ratio score: the mean difference between sex ratios for the successive age groups 0-4 to 60-64 averaged irrespective of sign;

Age ratio score: the mean deviation of age ratios from 100 per cent, irrespective of sign, for age groups 5-9 to 55-59;

Joint score: three times the sex ratio score plus the sum of the age ratio scores for the two sexes.

Source of data: Morocco Muslems: see Table 3 (adjusted for migration) and Table 4.
Muslems, North Zone: 1950: Maroc, S.C.S., 1965: I: 37;
Muslems, North Zone: 1960: Maroc, S.C.S., 1965: I: 133, 148, 157;
Tunisia and Algeria: U.N., Demographic Yearbooks.

United Nations publication (1955: Population Bulletin Number 2: 76).

The other remark to make at this point is that of a certain similarity among these age distributions. In his analysis of the age distribution of Tunisia, Picquet (1969) brings out the deficiency in both sexes at age groups 15-24. Bouisri and Pradel DeLamaze (1971) remark that in spite of the war and the out-migration in Algeria there are still more men than women, especially before age 20. Vallin (1970) remarks that the 1966 pyramids of Tunisia and Algeria have deficiencies

predominantly around age 20, while for Morocco (1960) the deficiencies concentrate around age 15. He also notes that there are generally more men than women. The masculinity ratios are as follows:

Morocco, 1960: 100
Algeria, 1966: 101
Tunisia, 1966: 104

The report of the Multiple-Purpose Survey brings out the deficiency at ages 10 to 20 which they note is similar to that obtained at the 1952 and 1960 censuses. Another similarity between Morocco, Algeria, and Tunisia is that there are less females than males around 10-14 with the opposite situation at ages 20-24. These distortions are much more pronounced in the Moroccan case.

3.5 Various Possible Causes of the Distortions

As summarized earlier (section 2.6), there are three general explanations that can account for distortions in age distributions: real phenomena, misreporting, and selective under-reporting. Each of these has been used to interpret the age distributions obtained in Maghrebian countries. Some of the arguments used will first be presented and then some survey material that is relevant to this question will be considered.

Some authors suspect that certain of the deficiencies in age groups are real. The argument makes sense in regard to the Algerian population where calculations indicate that there were some 500,000 to 800,000 losses due to the war of independence and some 500,000 losses by migration (Bouisri and Pradel DeLamaze, 1971). These factors would naturally have been somewhat age- and sex-selective. In Tunisia, Marcoux (1971) speaks of certain epidemics, in 1940 and 1946, which would have particularly affected the younger segments of the population. He also expects

a high female mortality due to the hard conditions to which females are subjected in traditional Arabic cultures. Vallin (1970) notes that the Second World War would have brought on an especially excessive infant mortality. He emphasizes that the deficiency is lower in the Moroccan (1960) pyramid than in the Tunisian (1966) age structure, thus adding evidence to his hypothesis. The Moroccan Multiple-Purpose Survey (Maroc, S.C.S., 1964) suggests that there may have been less births and more deaths between 1942 and 1952 due to the war and due to the famine of 1945. However, the census manual (Maroc, S.C.S., 1965: I: 45) makes the opposite claim: that because of the absence of appreciable military losses and the lack of durable epidemics in the course of the last thirty years, the abnormalities in the age pyramid cannot be attributed to age-selective mortality.

Most authors suspect considerable misreporting as a major source of the lack of uniformity in age distributions. Misclassification at older ages is evident (attraction for ages ending in zero), but it is the younger population that is of more immediate concern. The authors of the Consumer Survey (Maroc, S.C.S., 1961) who have to explain a very weird age distribution (Figure 9) call on a certain "psychological climate in regard to age," suggesting that children 10 to 12 get recorded as about 8 years old and that certain females 13 to 20 get recorded as 20 to 35. Picquet (1969) suspects that young Tunisian married women tend to over-estimate their ages, causing a shift from 15-24 to 25-30. Bouisri and Pradel DeLamaze (1971) suspect a similar occurrence in Algeria, especially with the women who get married before the legal age of marriage (sixteen). The authors of the Multiple-Purpose Survey propose that there is a systematic misreporting by which children are made younger

before puberty and older after puberty. Noin (1970) suspects that age group 5-9 is over-reported in the 1960 census of Morocco and that men do a better job than women at reporting their ages. The authors of the 1960 census publication compare the 1952 and 1960 censuses and note a large deficit in the passage from 5-9 in 1952 to 13-17 in 1960 as well as an increase in size with the passage from 10-19 in 1952 to 18-27 in 1960. They propose that this is to be explained by a "disaffection" for the initial ages of adulthood (13-17). Also, the reduction of age would be a rare phenomenon and the recording of ages up to 11 or 12 would be good.

This author suspects that under-enumeration is generally down-played, especially in official publications. Picquet (1969) uses the masculinity ratios to show that there is a strong under-enumeration of females in Tunisia, especially at the ages between childhood and maturity. He also expects an under-enumeration of men in these ages and of both sexes at ages zero and over sixty for a total omission of some 4%. Bouisri and Pradel DeLamaze (1971) also expect an under-enumeration of females (especially at ages 12-14) in Algeria; in spite of war and emigration, there are still more males than females. Vallin (1970) notes that the Moroccan census missed more young children than did those of Tunisia and Algeria. Noin (1970: I: 37-39) objects to the hypothesis of under-enumeration of young children in Morocco but supports the proposal of omissions of women, especially in rural areas. He proposes a figure of 230,000 omitted females plus some 170,000 to 230,000 others for a minimum under-estimate in 1960 of 3.5 to 4.0%. The 1952 and 1960 census publications both talk of an under-estimate at ages 0-4 but generally do not suspect other forms of age-specific under-enumeration.

We see that various opinions, sometimes conflicting, have been put forth to explain Moroccan or other related age distributions. But these are generally ex post facto hypotheses sometimes supported by impressionalistic observations (or biases). There is, however, a small amount of independent evidence on misreporting of ages and on omissions in Morocco which should be considered.

The 1961-63 Multiple-Purpose Survey undertook to improve age estimates through the use of an historical calendar. In rural areas, several estimates of age were obtained: a straightforward historical calendar estimate on the first round; an eye estimate and two estimates (through first and second events recalled) by a more complex historical calendar on the second round of the survey. Though a paper by the principal investigators of this survey (Scott and Sabagh, 1970) comes out rather pessimistic as to the value of the whole procedure for estimating age, some useful information can be gathered. Thus, commenting on the range of age reported for the same person, these authors write: a difference of two or more years between the age estimated from the first event and that estimated from the second event at the second round was obtained for 34% of the population aged 15 or older; also, between the first and second round uses of the historical calendar, a difference of two or more years was observed for 77% of the population aged 15 and over, and a difference of three or more years for 64% (1970: 101). In the urban sample, an interesting comparison was made between age declaration in the 1960 census and that obtained by the historical calendar in the 1962 survey. This comparison was based on the 59% of the Casablanca sample (the total size of which was 2,373 households) where the households were identical to those of the census (Table 10). Again the implied

misreporting is extensive with an over-all agreement of 65%. This tabulation also gives some indication on the direction of misreporting. The survey tended to record people as younger than the census. On the probable though slightly questionable assumption that the survey was more accurate in recording ages due to its use of the historical calendar, we could conclude that in the census people tended to exaggerate their ages. This systematic aging would be minimal (2.4%) before age 20 but would be in the order of 15 to 20% for other ages.

TABLE 10. COMPARISON OF AGES OBTAINED BY THE 1962 SURVEY AND THE 1960 CENSUS FOR THE SAME INDIVIDUALS, CASABLANCA SAMPLE (All data in percentages)

AGE AT CENSUS	AGE GIVEN BY THE SURVEY COMPARED TO AGE GIVEN BY THE CENSUS					
	YOUNGER BY		OLDER OR YOUNGER BY 2 YEARS OR LESS	OLDER BY		YOUNGER BY 3 OR MORE YEARS MINUS OLDER BY 3 OR MORE YEARS
	8 OR MORE YEARS	3 TO 7 YEARS		3 TO 7 YEARS	8 OR MORE YEARS	
0-19	0.5	6.7	88.0	4.2	0.6	2.4
20-49	9.4	24.8	44.3	13.0	5.5	15.7
40-59	18.8	21.2	35.7	11.7	12.6	15.7
60+	25.3	23.3	22.6	12.4	16.4	19.8
ALL AGES	6.6	15.0	64.9	8.3	5.2	8.1

Note: Corrected for the two year difference in observations.

Source: Maroc, S.C.S., 1964: 290.

The other survey that can be brought into this discussion is one involving a direct observation of the 1971 census operations. Some eighty-five local census officials plus eight external observers made a total of 293 in-the-field observations and recorded their remarks on a structured questionnaire. Among other things, the questionnaire tried

to elicit a comment on the part of observers as to the possible extent and direction of age misreporting. Approximately half of the observations included some comment on this issue. Again, there is evidence of a large amount of misreporting (Table 11). An additional table was

TABLE 11. EXTENT OF ERROR IN AGE REPORTING SUGGESTED BY OBSERVERS OF THE 1971 MOROCCAN CENSUS

AGE GROUP	ERROR				
	NO ERROR	1 - 2 YRS.	3 - 4 YRS.	5 - 6 YRS.	7 OR MORE YRS.
0-14	26 (18%)	107 (75%)	6 (4%)	2 (1%)	1 (1%)
15-34	9 (6%)	53 (40%)	41 (29%)	32 (23%)	4 (3%)
35-59	5 (4%)	19 (13%)	38 (26%)	47 (32%)	33 (23%)
60+	5 (4%)	7 (5%)	10 (8%)	36 (28%)	69 (53%)

Source: Beaujot and Elamrani-Jamal (1972).

constructed to summarize the observers' comments on the direction of misreporting (Table 12). These data on direction of misreporting could tentatively be summarized in the following way: a slight tendency, indicated by a tabulation not presented here, for age groups 0-9 to be increased at the profit of older ages; on the female side, this downward shift would continue throughout the ages with slightly less prevalence after age 40 due to contrary tendencies; on the male side, most of the error after age 10 would tend to nullify itself except for a possible slight downward shift that would increase ages 20-29 and a somewhat overriding upward shift after age 40. On the whole, these data would imply very little systematic non-compensating age misreporting except for a reduction of female ages. This reduction is in opposition to the exaggeration of ages that seemed to be implied in the comparison of

census and Multiple-Purpose Survey data (which were tabulated without controlling for sex).

TABLE 12. DIRECTION OF ERROR IN AGE REPORTING SUGGESTED BY OBSERVERS OF THE 1971 MOROCCAN CENSUS

	NUMBER OF OBSERVATIONS INDICATING THAT AGES WERE REDUCED, INCREASED, OR EXACT					
	MALES			FEMALES		
AGES	REDUCTION	INCREASE	EXACT AGES	REDUCTION	INCREASE	EXACT AGES
0-4	9	7	20	47	3	9
5-9	9	7	20	47	3	9
10-14	10	8	19	48	5	8
15-19	8	9	17	54	5	6
20-24	10	8	18	57	4	6
25-29	11	8	16	56	4	6
30-34	8	9	16	52	4	6
35-39	10	9	16	56	5	6
40-44	9	16	16	56	11	6
45-49	9	16	16	57	11	6
50-54	10	19	16	58	12	6
55-59	10	19	16	56	12	6
60-64	10	20	16	56	12	6
65+	11	20	16	56	12	6

Note: The data given should be interpreted with caution since it was established on the basis of meagre indications on the part of observers. For example, if the observer simply stated that female ages were reduced, we assumed that this was meant to be true across all ages. Similarly, if the observation indicated that husbands were reducing or increasing the ages of their marital partners, this was assumed to be as of age 15.

Source: Beaujot and Elamrani-Jamal (1972).

This direct observation of the 1971 census also gathered some very limited information on possible omissions. There seemed to be a certain popular reaction against enumerating in a given household people who were not related to the family. This is an important problem given the large number of young female servants who reside in the households for

which they are working. It would also under-estimate the mobile (persons of passage) population. It was expected that the "de facto" population was less adequately enumerated than the "de jure" population.

We have therefore brought together a considerable amount of indications, most of them sparse and often conflicting, that are relevant to understanding the distortions in the age distributions. The author reserves his own comments, biases, and conclusions to the end of this chapter (section 3.10).

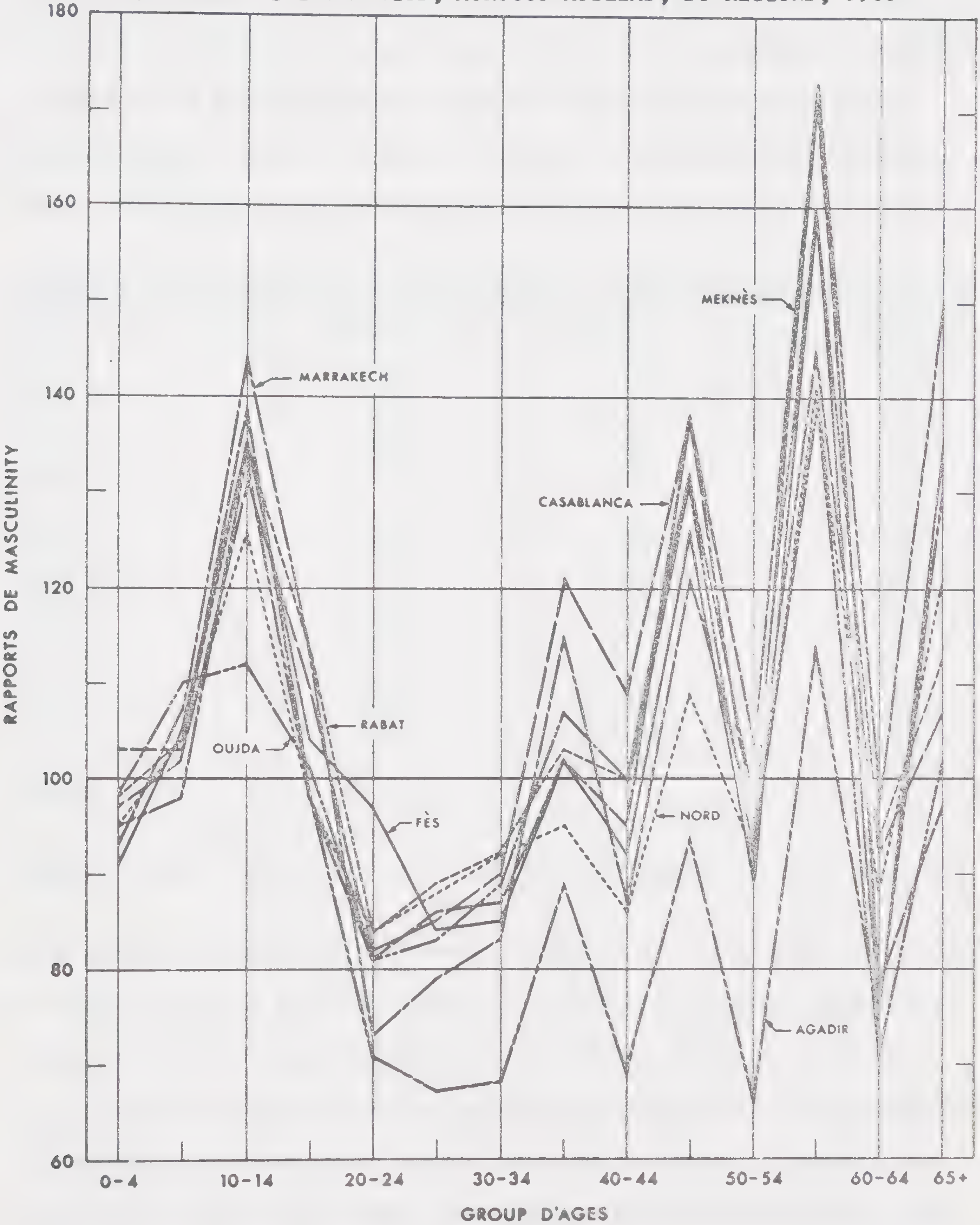
3.6 Masculinity Ratios

Though this ratio is rather normal on the total of ages in the closed Morocco Muslem population in 1960 (100.5), it varies largely when the age groups are considered separately (Figure 3, section 3.3). Also, this variation is rather uniform among regions (Figure 12). In general, there is a surplus of men (and/or lack of women) especially at ages 10-14, a surplus of women (and/or lack of men) at 20-34, and a surplus of men (and/or lack of women) on the whole group of ages after 35 or 40. The patterns obtained at the 1966 censuses of Tunisia and Algeria, though less exaggerated, follow the Moroccan pattern almost identically. There is also a remarkably similar pattern in the sample of the Multiple-Purpose Survey, including the various passages and types of age estimates.[26] An analysis of rural communes by Noin (1970: II: 11) indicates that the masculinity ratio in 1960 was over 110 in twenty of these. The 1952 census publication (Maroc, S.C.S., 1952: I: XX) also notes that there were proportionately more women in municipalities than in smaller centers and

---

[26]Source: Maroc, S.C.S. (1964: 31, 38, 39) and Scott and Sabagh (1970: 99). In this survey, the high ratio at 10-14 is continued at 15-19.

FIGURE 12. MASCULINITY RATIOS, MOROCCO MUSLEMS, BY REGIONS, 1960



Source of data: Maroc, S.C.S., 1965: I: 132-59 (no adjustments).

in rural areas. These observations would certainly point to omissions of females in rural areas.

The masculinity ratios for cumulated ages (Table 13) are useful to resolve the problems at certain ages. The downward cumulation indicates that the small abnormalities at ages 0-4 and 5-9 can be resolved by adding these two groups together. If there was transference across age ten or under-enumeration before this age, it would have to be taking

TABLE 13. MASCULINITY RATIOS FOR CUMULATED AGES, MOROCCO MUSLEMS, 1960

AGE	RATIO	AGE	RATIO
0-4	95.5	0+	100.5
0-9	99.3	5+	101.8
0-14	105.6	10+	101.2
0-19	105.7	15+	96.6
0-24	102.2	20+	95.4
0-29	99.8	25+	98.1
0-34	98.5	30+	102.0
0-39	99.3	35+	106.5
0-44	99.0	40+	105.5
0-49	99.7	45+	109.7
0-54	99.5	50+	106.3
0-59	100.2	55+	111.9
0-64	99.7	60+	105.3
		65+	122.6
TOTAL	100.5		

Source of data: Age distribution adjusted for migration, see Table 3.

place about equally for both sexes. According to the upward calculations, one must go down to age 30+ (102.0) or 25+ (98.1) to obtain normal figures. It is therefore probable that the reduced ratios at ages 25 to 34 (or 30-34) and the generally high ratios after age 35 can be explained by a systematic reduction of female ages (or a systematic increase in male ages) at these age levels. Explaining ages 10-24 by errors of reporting would require the heroic assumption that males are reducing their

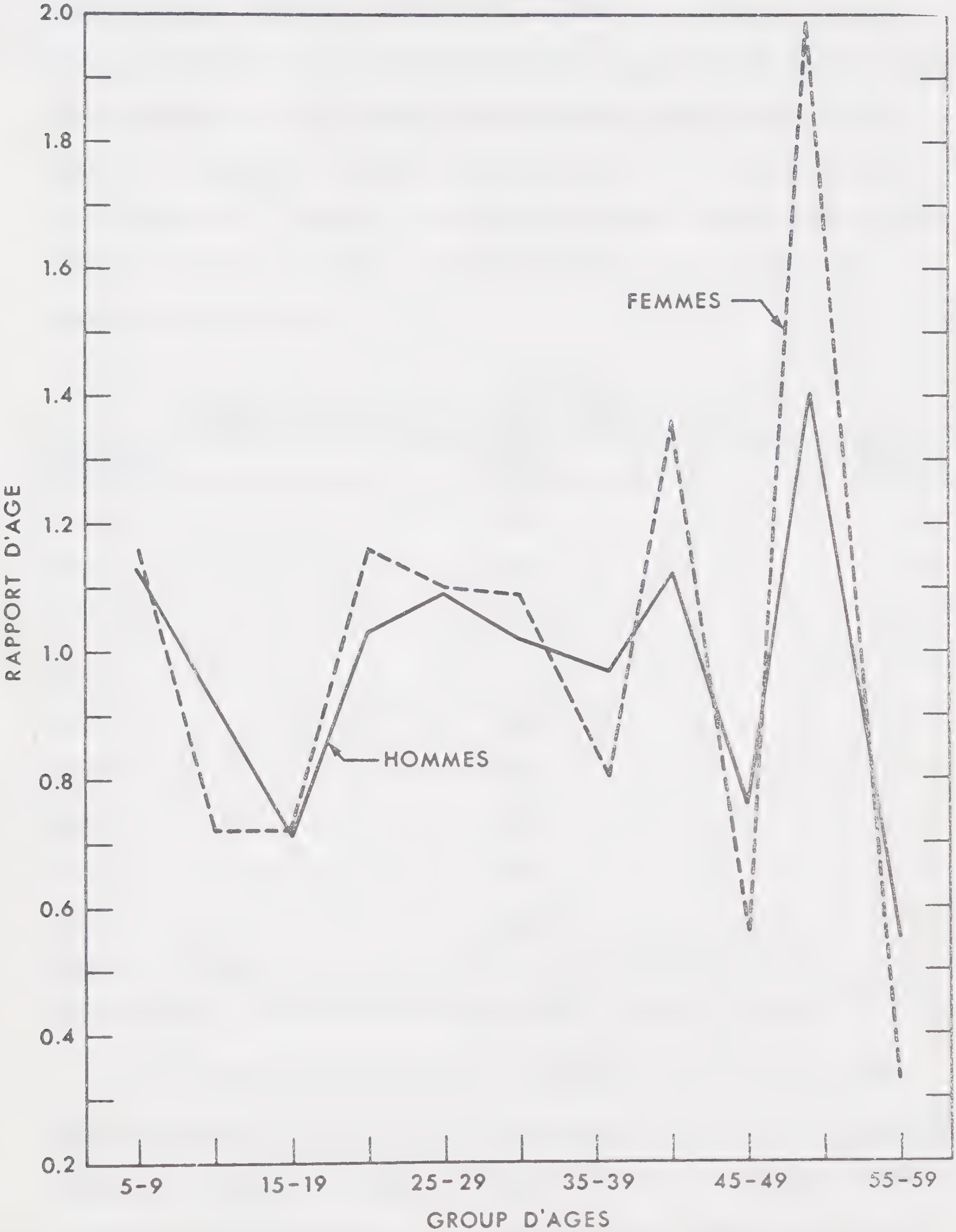
ages while females are increasing theirs. The more probable explanation would seem to be that women are missed (young servants) or hidden (before marriage) at ages 10-14 while men are missed (very mobile, searching for work, etc.) at ages 20-24. It could also be that both sexes are missed at ages 15-19 so that the masculinity ratio balances for this group.

3.7 Age Ratios

The age ratio is the proportion of an age group to the average of its two neighboring age groups. Normally, this ratio is very close to 1.0. The graph for Morocco Muslems (Figure 13) presents once again an erratic pattern with considerable similarity among regions. The general pattern is as follows: a surplus of men at 5-9 with a deficiency at 15-19 and later a certain stability followed by strong variations after age 30 with attractions for ages ending in zero; a surplus of females at 5-9 and at 20-34 with a large deficit at 10-19 and increasing variations after age 35. The graph from the Multiple-Purpose Survey sample (Maroc, S.C.S., 1964: 37) is similar to that described above except that there is a stronger surplus of females at 25-29. In Tunisia's and Algeria's 1966 censuses (U.N., Demographic Yearbook), the surplus, especially of males, is at 10-14 with deficiencies in both sexes at 15-24. Thus the squeeze on the age distribution is in fact some five years later than in the Moroccan case.

Interpreting these patterns is hazardous, especially since some of the ratios can be spurious (i.e., caused by problems in the neighboring ages). For the male side, giving the maximum weight to the hypothesis of misreporting, it could be that some of the 10-14 have had their ages decreased to 5-9. But, since the graph stabilizes after age 20, it would be difficult to fill in the deficiency of males aged 15-19 with

FIGURE 13. AGE RATIOS, MOROCCO MUSLEMS, 1960



Source of data: See Table 3 (1960 adjusted for migration).

adjustments for misreporting. This gives evidence of probable under-enumeration in the latter group. Continuing with the males, age group 25-29 is large; the single-year age distribution indicates a strong attraction for age 25. A slightly different age ratio (using as denominator the average of the four neighboring age groups) would tend to support the hypothesis of under-enumeration at 10-19 and surplus at 25-29 (Table 14). The fact that these ratios are already over 1.0 at ages over 30 would indicate that the surplus at 25-29 is due to an increase in male ages.

TABLE 14. RATIO OF AGE GROUPS TO THE AVERAGE OF THE FOUR NEIGHBORING GROUPS, MOROCCO MUSLEMS, 1960

AGE GROUP	MALES	FEMALES
10-14	0.87	0.64
15-19	0.60	0.58
20-24	0.91	1.13
25-29	1.17	1.30
30-34	1.06	1.10
35-39	1.03	0.85
40-44	1.04	1.10
45-49	0.81	0.67
50-54	1.08	1.19

Source of data: Age distribution adjusted for migration, see Table 3.

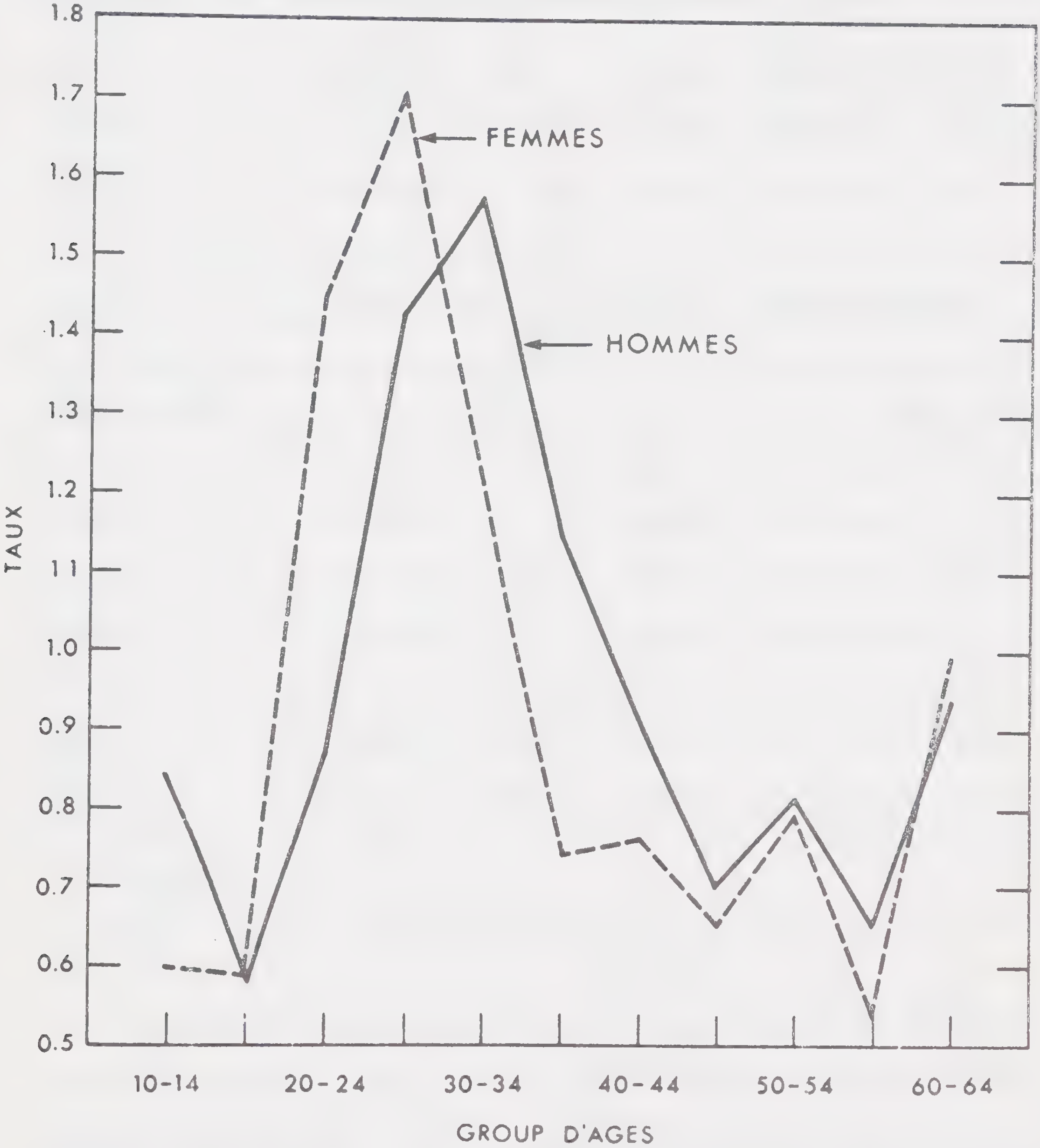
On the female side, the surplus at 5-9 could again be at the expense of ages 0-4 and 10-14. The surplus at 20-34 could be explained either by a systematic aging of groups 10-19 or by a systematic lowering of ages of those above 35. If the impressionistic observations made in

the course of the 1971 census are to be trusted as valid for the 1960 age reporting, we would tend to support the lowering of ages of females 35+. Some young married females may be increasing their ages, thus explaining the surplus at 20-24, but it would seem unlikely that they increase their age beyond 24. Such an aging would go against a prevalent orientation in most cultures for women to shift their ages in the opposite direction. The four year average age ratios for females confirm the strong attraction for ages 25-29 with some attraction for 20-24 and 30-34. These, however, would tend to indicate that the surplus at 25-29 should at least in part be explained by systematic aging, since older ages are not deficient enough to explain the surplus at 25-34 by a reduction of ages.

3.8 Census Survival Rates

These rates are the proportions of the various age groups that survive to the appropriate groups in the succeeding census; in a closed population, they should normally be somewhat lower than 1.0. As the graph shows (Figure 14), the males are lost especially at 15-19, then recovered at 25-34; similarly, the females are lost at 10-19 with a strong "recovery" at 20-29 and again a loss thereafter. Using the single-year age distributions of the South Zone in 1952 and in 1960, the census publication (Maroc, S.C.S., 1965: I: 44) notes a large deficit in the passage from 5-9 to 13-17 and a strong recovery from 10-19 to 18-27. These rates are somewhat difficult to interpret since either (or, more likely, both) of the censuses can be in error. Table 15 covers the total possibilities of explanations in terms of surpluses and deficiencies.

FIGURE 14. CENSUS SURVIVAL RATES, MOROCCO MUSLEMS, 1950-1960



Sources of data: See Table 3 (1960 adjusted for migration) and Table 4.

TABLE 15. POSSIBLE EXPLANATIONS OF SURVIVAL RATES, MOROCCO MUSLEMS, 1950-1960

MALES			
AGES IN 1960	1950		1960
10-14	surplus at 0-4	and/or	deficiency at 10-14
15-19	surplus at 5-9	and/or	deficiency at 15-19
20-24	surplus at 10-14[a]	and/or	deficiency at 20-24[a]
25-29	deficiency at 15-19	and/or	surplus at 25-29
30-34	deficiency at 20-24	and/or	surplus at 30-34
35-39	deficiency at 25-29	and/or	surplus at 35-39
FEMALES			
AGES IN 1960	1950		1960
10-14	surplus at 0-4	and/or	deficiency at 10-14
15-19	surplus at 5-9	and/or	deficiency at 15-19
20-24	deficiency at 10-14	and/or	surplus at 20-24
25-29	deficiency at 15-19	and/or	surplus at 25-29
30-34	deficiency at 20-24	and/or	surplus at 30-34
35-39	surplus at 25-29	and/or	deficiency at 35-39
40-44	surplus at 30-34	and/or	deficiency at 40-44

[a]Minimal.

Note: For the rates themselves, see Figure 14.

On the male side, the hypothesis of misreporting would suppose a reduction of ages 15-29 to 5-14 in 1950 and/or an increase of ages 10-24 to 25-39 in 1960. It would seem to be easier and more coherent to suppose an under-enumeration at 15-29 (especially at 15-24) in 1950 and/or an under-enumeration at 10-24 (especially at 15-24) in 1960.

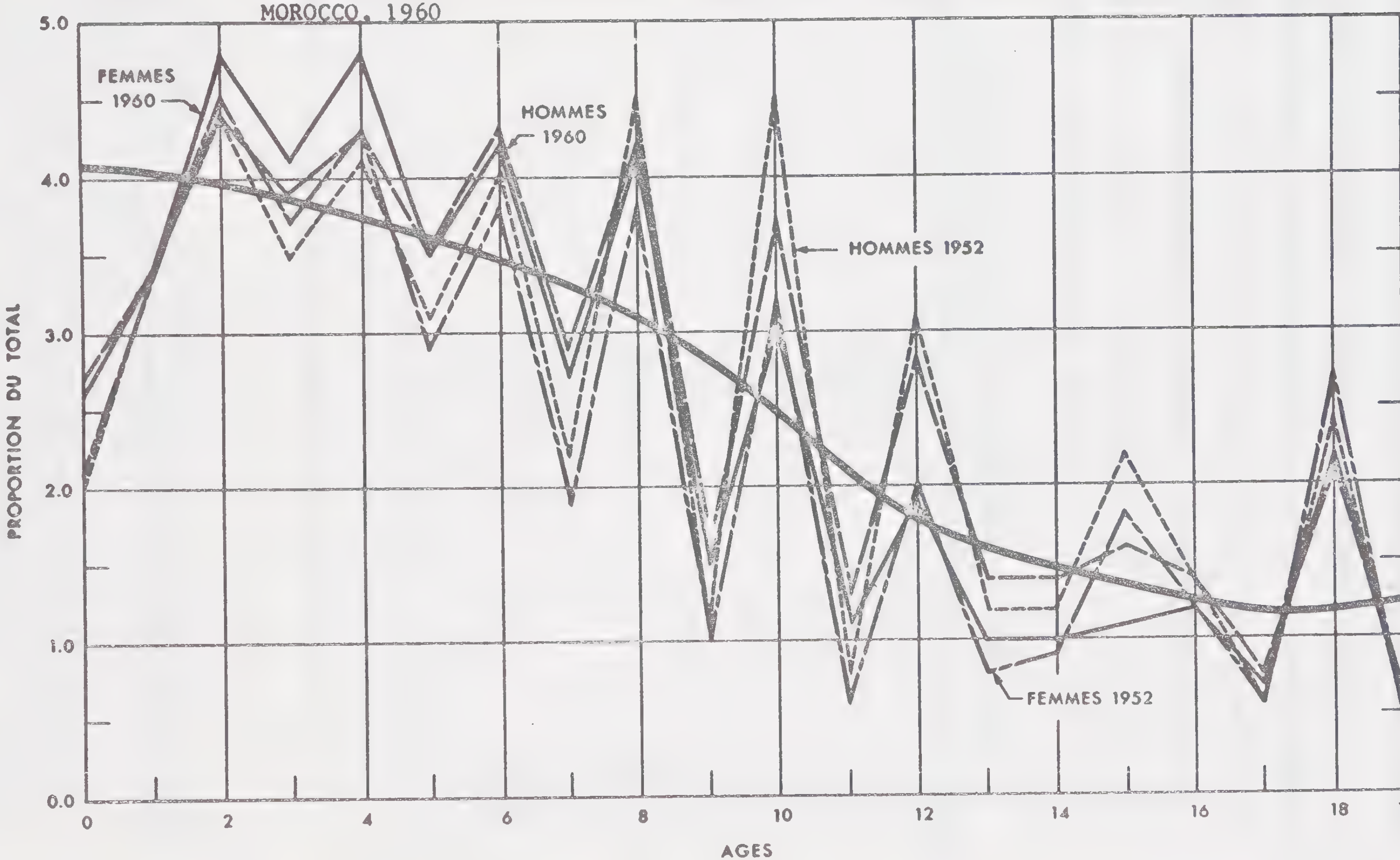
On the female side, the hypothesis of misreporting would suppose that in 1950 the women aged 10-24 were reduced or increased in age to leave these age groups and/or that in 1960 those aged 10-19 were aged and those 35-44 were reduced in age to swell age group 20-34. Again, the hypothesis of under-enumeration requires less heroic assumptions: women aged 10-24 (especially 10-19) in 1950 and/or aged 10-19 in 1960 were missed.

3.9 Single-Year Age Distribution

This distribution for ages 0-19 (Figure 15) shows a deficiency especially at ages 0 and 1 and an attraction for even ages. The surplus at even ages is naturally due to misclassification of ages. The lack of an inflation at age five is rather surprising. An inspection of original tables would indicate that this is not due to errors in tabulation. The same deficiency of age five relative to ages four and six occurred in the 1966 census of Tunisia (Ledjri, 1969). It is suspected that the deficiency at ages 0 and 1 is due in part to an aging of children at these ages. In fact, a cursory study of some of the census questionnaires shows that certain children aged less than one were transmitted in the tabulation as aged one (i.e., the "age at last birthday" was not respected). As Vallin (1970) notes, the Moroccan census was less adequate than those of Algeria and Tunisia in enumerating the young children.

In the 1960 census publication (Maroc, S.C.S., 1965: I: 45), it is estimated that 110,000 children aged less than one were enumerated as being aged one or two. But evidently the surplus at age two is not sufficient to explain the deficiencies in the two first years. Having adjusted for these 110,000, the curve of the averages for ages 1-4, 5-9, . . ., 15-19 was projected to age zero (see Figure 15). This procedure,

FIGURE 15. PROPORTIONATE DISTRIBUTION BY SINGLE YEARS, MOROCCO MUSLEMS, SOUTH ZONE, 1952, MOROCCO, 1960



ESTIMATIONS, DEUX SEXES 1960 ---Estimates, both sexes, 1960

Sources of data: Maroc, S.C.S., 1952: III: 3; 1965: I: 39.

which supposes no under-enumeration at 1-4 and an aging of 110,000 from 0 to 1-4, still indicates that 155,000 children were missed.[27]

The masculinity ratios by single years can be calculated from this distribution. These were derived for ages cumulated upward to age 14 (Table 16). Two observations can be made: the masculinity ratio at birth seems to be very low,[28] and the ratios only start deviating from expected values somewhere after age nine.

TABLE 16. MASCULINITY RATIOS FOR CUMULATED AGES BY SINGLE YEARS 0 TO 14, MOROCCO MUSLEMS, 1952 AND 1960

AGES	1960	1952
0	100.8	96.8
0-1	99.8	97.8
0-2	97.0	96.7
0-3	96.6	95.7
0-4	95.3	95.6
0-5	96.4	97.0
0-6	97.0	97.9
0-7	97.9	99.0
0-8	98.6	101.1
0-9	99.2	101.4
0-10	101.2	105.0
0-11	101.7	105.6
0-12	103.7	108.2
0-13	104.6	109.0
0-14	105.4	109.5

Note: No adjustments for migration; 1952 is South Zone only.

Sources of data: Maroc, S.C.S., 1965: I: 39; 1952: III: 3.

[27]The census publication estimates an under-enumeration of 94,000 at age zero. This is 19% of the total for age zero after adjustment: 94,000/ (292,000 + 110,000 + 94,000) = 19%.

[28]The masculinity ratio at birth is generally close to 105. However, it has been noted (e.g., van de Walle, 1968: 43) that is is generally lower in Tropical Africa, especially among Black Africans.

3.10 Adjustment of the 1960 Age Distribution

The above considerations permit a certain judgment on the reliability of various parts of the age distribution and on the adjustments that may be warranted. The following adjustments are proposed:

(a). Ages 0-4: 77,500 children are added to each sex according to the analysis of the single-year age distribution. This would be in conformity with opinions expressed in the census publications and by most authors (with the exception of Noin, 1970).

(b). Ages 5-9: 25,000 (4.8%) of each sex are aged to group 10-14. This transfer, which reduces the force of the argument for under-enumeration, is based on the age ratio which is high at 5-9 (this could also be due to the spurious effect of deficiencies at 0-4 and 10-14) and on the survival rates which are low at 15-19 (which can either be explained in terms of surpluses at 5-9 or deficiencies at 15-19). This movement would be in conformity with the opinion that ages are reduced before puberty. It would also be in conformity with observations made in the course of the 1971 census operation. The author is reluctant to transfer more than this number across this age on two grounds: since age nine is already under-enumerated, the transfer supposes that certain children aged ten and more are recorded as eight or less; second, it is expected by the census publication, and supported by sex ratios by single years, that ages are fairly well recorded until 11 or 12.

(c). Ages 0-9: After the adjustments indicated above, this group

as a whole (masculinity ratio 99.3) is expected to be an accurate measure of the age distribution. There is a possible transference between 0-4 and 5-9 but this is neglected.

(d). Males 25-29: Age ratios had suggested that some systematic aging is inflating this group. To compensate, 20,000 (4.7%) are reduced to lower ages. This is supported also by the comparison with the Multiple-Purpose Survey which seemed to indicate that census ages, especially above 20, were increased.

(e). Females 20-24: It is assumed that the inflation in this group, as evidenced by age ratios and survival rates, is due to an increase in ages of the 10-19 group but that there is no transference across age 25. The fact that we assume this inflation to be due to an aging of 10-19 rather than to a lowering of ages of those 25+ reduces the argument of under-enumeration. This position is supported also by indications that female ages are exaggerated after an early marriage. The absence of transference across age 25 is more difficult to defend. We recall that ages 20-34 are all inflated. If there is a transfer downwards, which the 1971 census observations would tend to indicate, then where did they go since they are not counted at 15-24? In other words, a reduction of ages would mean even more under-enumeration. An upward transfer, which seems to be indicated by the comparison between the census and the Multiple-Purpose Survey though the latter did not control for sex, appears as an unlikely phenomenon (women under 25 wanting to be considered

older than 25!).

(f). Ages 25+: Having reduced the men by 20,000, this group is taken as the other firm measure of the age distribution. That is, we assume no under-enumeration specific to these ages. The masculinity ratio of this group now establishes itself at 97.3 All abnormality after age 25 would be due to misreporting which can be smoothed. This position is supported by the age ratios which tend to be rather regular around age 25, while the deviations at higher ages compensate for each other. Also, the population in these ages tends to be more fixed and thus less subject to under-enumeration.

(g). Ages 10-24: After having transferred into this group 25,000 of each sex (from 5-9) and 20,000 males (from 25-29), the remainder will have to be filled in from the exterior by comparison to a population that has similar proportions at ages (0-9)/25+. On the whole, the considerations presented would indicate an under-enumeration for at least one sex at each age group between ages 10 and 24. It is also possible, as suggested earlier, that some of these groups are really deficient due to problems of war, disease, and famine. The 1971 census will help to confirm or disprove this proposition. It would seem to this author, however, that these mortality factors would not have been so age-specific as to bring about such a strong deficienty at these ages.

The above adjustments (Set 1) will be used as the basis for the estimates that are to be derived. Two alternative sets of adjustments, however, will be considered mainly for the purpose of comparison.

The second set tries to minimize even more the need for assuming under-enumeration. A transfer of 40,000 (rather than 25,000) is made from 5-9 to 10-14 for each sex. This is based on similar considerations to those presented above. Also, 60,000 of each sex are transferred from 25+ to younger ages. This is based on the comparison between the Multiple-Purpose Survey and the census which would indicate that some 15% of those in age group 20-49 may be increasing their ages. The third set simply assumes no tranference across ages 10 and 25. This is based on the observations that ages up to 11 or 12 are relatively well reported and that misreporting, especially of men as indicated by observations of the 1971 census, tends not to be systematic but rather to counter-balance.

CHAPTER 4

ANALYSIS AND CONCLUSIONS

The basic parameters of growth rate and age distribution have now been refined so that the main analysis can proceed. Much of what follows is but a giant exercise in interpolation on the basis of types of life tables and stable populations that have been established as models by Coale and Demeny (1966; U.N., 1967: Population Study Number 42). The three techniques of census survival, stable population, and quasi-stable population will be applied. The applicability of methods will also be discussed and comparisons made with estimates derived by other authors. Questions of reliability and methodological significance will be considered by way of conclusion.

4.1 Estimates through Census Survival

This technique of estimation was applied only to the Morocco Muslem population. The 1960 population (Table 3) was adjusted both for migration and for unknown ages. The 1950 population, which had been adjusted for differences in census dates (Table 4), was further altered to take account of the three hypotheses of differential under-enumeration among censuses (see Table 8).[29] The census survival method was then applied: the 1950 population of one sex is first projected to the appropriate age

---

[29]Hypothesis 1: No adjustments for differential under-enumeration.

Hypothesis 2: Add at:

	MALES	FEMALES
0-4	32,750	34,620
5-9	28,650	26,780

groups in 1960 by way of the survivorship functions of various mortality levels in the West family of life tables (U.N., 1967: Population Study Number 42: 94); these projections are cumulated upwards to obtain the number surviving from 0+ in 1950 to 10+ in 1960, . . ., from 40+ in 1950 to 50+ in 1960 at the various mortality levels; the level corresponding to the actual survival of these population segments is then chosen by interpolation. Having established nine mortality levels according to the survival of these nine overlapping segments, the median level is chosen as representing the actual conditions of mortality. The age-specific death rates implied by this level are then applied to the mean of the 1950 and 1960 populations to obtain the total deaths which when divided by the mean population gives the death rate. The birth rate for this particular sex is obtained by adding the growth rate and the death rate. The birth rate of the other sex is calculated through the sex ratio at birth and in the population. Finally, the death rate for this other sex is a residual (d = b - r).[30] These estimates were first worked out on the basis of the survival of females (Table 17), then on the basis of the survival of males (Table 18). In each case, the three hypotheses

---

		MALES	FEMALES
Hypothesis 2: Add at:			
	20-24	47,236	
	25-29	55,416	
	30-34	33,267	
Hypothesis 3: Add at:			
	0-4	65,500	69,240
	5-9	57,300	53,560
	20-24	47,236	
	25-29	55,416	
	30-34	33,267	

[30]For a detailed example of the calculations involved in the application of this technique, see Coale and Demeny (U.N., 1967: Population Study Number 42: 57-61).

TABLE 17. VITAL RATES AND LIFE EXPECTANCY AS CALCULATED THROUGH CENSUS SURVIVAL OF FEMALES, MOROCCO MUSLEMS, 1950-1960

	HYPOTHESIS 1		HYPOTHESIS 2		HYPOTHESIS 3	
	MALES	FEMALES	MALES	FEMALES	MALES	FEMALES
Growth rate (%/yr.)	3.4	3.4	2.8	2.8	2.4	2.4
Mortality level[a]	9.3	9.3	8.4	8.4	8.0	8.0
Death rate/1,000						
105[b]	28.1	24.8	29.3	27.0	31.4	28.2
102[c]	26.0	24.8	28.1	27.0	29.2	28.2
Birth rate/1,000						
105[b]	62.1	58.8	57.3	55.0	54.4	52.2
102[c]	60.0	58.8	56.1	55.0	53.2	52.2
Life expectancy at birth	38.0	40.8	35.9	38.5	34.9	37.5
Life expectancy at age five	48.4	50.2	47.1	48.8	46.5	48.2

[a]The mortality level refers to the chosen model mortality table among those of a family of such tables (here the West family).

[b]The masculinity ratio at birth of 105 was used as the basis of calculation of male rates.

[c]The masculinity ratio at birth of 102 was used as the basis of calculation of male rates.

Note: The three hypotheses refer to adjustments to the growth rate (see Table 8), with Hypotheses 2 and 3 being preferred.

of differential under-enumeration were used.

It should be remarked that a considerable range of mortality levels was implied by the survival of the various segments of age groups. There was, however, a certain "bunching" around the chosen level. For females, this convergence referred to the survival of ages 0+, 20+, and 35+; the survival of ages 5+, 10+, and 15+ tended to point to much higher

TABLE 18. VITAL RATES AND LIFE EXPECTANCY AS CALCULATED THROUGH CENSUS SURVIVAL OF MALES, MOROCCO MUSLEMS, 1950-1960

	HYPOTHESIS 1		HYPOTHESIS 2		HYPOTHESIS 3	
	MALES	FEMALES	MALES	FEMALES	MALES	FEMALES
Growth rate (%/yr.)	3.4	3.4	2.8	2.8	2.4	2.4
Mortality level[a]	18.0	18.0	13.5	13.5	13.0	13.0
Death rate/1,000						
105[b]	11.6	9.2	18.2	16.4	19.3	17.6
102[c]	11.6	10.4	18.2	17.7	19.3	18.8
Birth rate/1,000						
105[b]	45.6	43.2	46.2	44.4	43.3	41.6
102[c]	45.6	44.4	46.2	45.7	43.3	42.8
Life expectancy at birth	58.8	62.5	48.3	51.3	47.1	50.0
Life expectancy at age five	60.3	63.2	54.4	56.5	53.7	55.9

[a]The mortality level refers to the chosen model mortality table among those of a family of such tables (here the West family).

[b]The masculinity ratio at birth of 105 was used as the basis of calculation of female rates.

[c]The masculinity ratio at birth of 102 was used as the basis of calculation of female rates.

Note: The three hypotheses refer to adjustments to the growth rate (see Table 8), with hypotheses 2 and 3 being preferred.

mortality levels (lower mortality) while ages 25+ and 30+ implied lower levels. For males, there was even less convergence but what "bunching" there was referred to ages 5+ and 25+ for Hypothesis 1 and to ages 25+, 30+, and 35+ for the other two hypotheses. It was found that the male survival of ages 10+, 15+, and 20+ pointed to very high mortality levels (low mortality). The results as tabulated also present extreme

differences depending on whether estimates were derived from the survival of males or of females. The mortality conditions of the females would appear to be much worse than those of males. It is possible that adjustments made for improved coverage of males were not sufficient. Could it also be that coverage of females had deteriorated in 1960, thus showing up as high mortality? Surely differences in the order of 10 per thousand between the mortality of males and females are not real!

It is argued, on the following grounds, that these estimates derived through census survival are not reliable: there are unacceptable differences in estimates derived from the survival of the two sexes; a large range of mortality levels are implied by the survival of the various age group segments; these estimates rely heavily on the 1950-52 enumerations which are considered inferior in quality; though adjustments were made to the latter, the various procedures for projecting the populations back to 1950 and for estimating differential under-enumeration are but rough approximations.

4.2 Applicability of Stable Population Methods to the Moroccan Population

Stable population methods can only be used if a case can be made for the existence of stability with respect to the relevant demographic conditions (U.N., 1967: Population Study Number 42: 61). The constancy of the age distribution and of the rate of population growth are of particular interest.

Though a five-year age distribution for Morocco Muslems is only available since 1950-52, tabulations by the three large age groups are available since 1926. The latter give strong indications of the

stability of the age structure (Table 19).[31]

The rate of growth has not been constant (see Table 6) and therefore it will be necessary to make corrections for quasi-stability. Various authors suspect, however, that fertility has been constant over a long period. Seklani (1960) argues that the basically pro-natalist religious, marital, and family structures have not greatly changed in Arab countries. There would be a few changes brought about by urbanization, detribalization, proletariatization, and the social promotion of women but this only in a few well limited regions. Benyoussef (1967: 119, 358) also claims that birth rates have not changed. He admits that birth rates may have risen in certain towns with the campaign against venereal diseases, but he argues that they have not been much affected by the process of urbanization. The census manual (Maroc, S.C.S., 1965: I: 45) also does not expect that there have been any appreciable long-term variations in fertility.

The West family of model life tables is chosen for this analysis. This is the preferred family when, as in the case of Morocco, little information is available which would enable us to make a direct choice among families on the basis of actual mortality patterns.[32] This West set was in fact derived from those actual life tables with no systematic tendency to deviate from a preliminary set of model tables designed to

---

[31] A similar stability in the proportion at ages 0-14 is noted for Algeria (Bahri and Dellouci, 1971).

[32] The Multiple-Purpose Survey (Maroc, S.C.S., 1964: 77) does tabulate age-specific death rates but without separating the sexes. Needless to say, these would also be distorted by misreporting and under-enumeration. The mortality schedule obtained in the survey was compared to that of the four families of model life tables but this did not identify a particular model as corresponding to the Moroccan conditions.

TABLE 19. PROPORTIONATE DISTRIBUTION OF THE MOROCCO MUSLEM POPULATION ACCORDING TO THREE LARGE AGE GROUPS IN 1926, 1931, 1936, 1940, 1950, 1952, 1960

CENSUS	BOTH SEXES			MALES			FEMALES		
	CHILDREN	ADULTS	OLD PEOPLE	CHILDREN	ADULTS	OLD PEOPLE	CHILDREN	ADULTS	OLD PEOPLE
1926 (South Zone)	38.8	53.6	7.6						
1931 (South Zone)	41.1	50.7	8.2	42.9	49.9	7.2	39.3	51.6	9.1
1936 (South Zone)	40.5	50.8	8.7	42.2	50.5	7.3	38.7	51.2	10.1
1940 (North Zone)	33.2	57.4	9.4	34.1	57.0	8.9	32.6	57.7	9.7
1950 (North Zone)	43.4	52.2	4.4	45.7	50.2	4.1	41.1	54.1	4.8
1952 (South Zone)	41.0	52.1	6.9	43.2	49.4	7.4	38.8	54.8	6.4
1960 (Morocco)	44.8	48.1	7.1	46.0	46.7	7.3	43.7	49.4	6.9

Note: All data in percentages.
All data unadjusted.
For the censuses of 1926 to 1940, these were the actual age categories used.
For censuses of 1950, 1952, and 1960, the groups correspond to ages 0-14, 15-59, and 60+, respectively.

Source: Maroc, S.C.S., 1965: I: 36.

express median recorded world experience (U.N., 1967: Population Study Number 42: 8). Each of the three other families was based on regional patterns of consistent and persistent deviations from average world age patterns of mortality.

4.3 Estimates through Stable Population Analysis

Nine series of estimates of vital rates were derived for the Morocco Muslem population according to the adjustments that were made to the growth rate and to the age distribution. The growth rates obtained according to the three hypotheses of differential under-enumeration among censuses were 3.4, 2.8, and 2.4 per cent, respectively (Table 8). The age distribution measure used is always (0-9)/25+. The three sets of adjustments to these proportions are as follows (see section 3.10):

Set 1: Preferred adjustments:

77,500 are added to each sex at 0-4;
25,000 of each sex are transferred from 5-9 to higher ages;
20,000 males are transferred from 25-29 to lower ages.

Set 2: Strong weight given to misreporting of ages:

77,500 are added to each sex at 0-4;
40,000 of each sex are transferred from 5-9 to higher ages;
60,000 of each sex are transferred from 25+ to younger ages.

Set 3: Low weight given to misreporting of ages:

77,500 are added to each sex at 0-4;
No transfers across ages 10 and 25.

In each case, the proportions (0-9)/25+ at the appropriate growth rates in the West family of model stable populations are calculated at the various mortality levels until the actual proportion (0-9)/25+ is encircled.[33] The exact level is then calculated by interpolation.

---

[33] This proportion also varies systematically among levels within a family of model stable populations.

Relevant parameters of this chosen model can subsequently be obtained. Since the model is chosen on the basis of the proportion between ages 0-9 and 25+, this procedure permits a simultaneous estimate of the proportion that should be at ages 10-24 and thus of the implied under-enumeration.[34] In each instance, estimates were derived separately for each sex (Table 20). For a detailed example of these calculations, see the Appendix.

It is immediately evident that the results derived from Hypothesis 1 (r = 3.4) are invalid: they imply unacceptably low mortality rates (5 to 6 per thousand). This hypothesis had in fact been retained only to work out the consequences of the assumption of no differential under-enumeration among the two censuses. There are few differences among sets of age distribution adjustments: vital rates increase slightly from Set 1 (preferred) to Set 3 (little misreporting) and Set 2 (much misreporting). It is encouraging that the birth rates vary only slightly over the various sets within Hypotheses 2 and 3 (Males 45 to 50 per thousand; Females 44 to 50). The mortality estimates, however, differ considerably (Males 17 to 26; Females 16 to 26) with the higher growth rate (or lower assumed differential under-enumeration) implying lower mortality. These results agree with the argument (section 2.2) that stable population methods can establish fertility more definitely than mortality. The under-enumeration establishes itself definitely above 10% even in Set 2 where strong assumptions were made in order to reduce the implied under-enumeration.

---

[34]The total estimated population is established by dividing the adjusted population at ages 0-9 plus 25+ by the proportion at ages 0-9 plus 25+ in the chosen model. The implied rate of under-enumeration is the difference between the enumerated and estimated populations divided by the estimated population.

TABLE 20. VITAL RATES, LIFE EXPECTANCY AND UNDER-ENUMERATION AS CALCULATED THROUGH STABLE POPULATION TECHNIQUES, MOROCCO MUSLEMS, 1960 (by 1,000s)

	HYPOTHESIS 1		HYPOTHESIS 2		HYPOTHESIS 3	
SET 1	MALES	FEMALES	MALES	FEMALES	MALES	FEMALES
Growth rate (%/yr.)	3.4	3.4	2.8	2.8	2.4	2.4
Mortality level[a]	21.8	21.1	13.2	12.8	9.1	8.7
Birth rate/1,000	39.7	39.3	45.0	44.0	49.6	48.3
Death rate/1,000	5.7	5.3	17.0	16.0	25.6	24.3
TOTAL POPULATION	6,210.0	6,300.0	6,240.0	6,320.0	6,260.0	6,330.0
Per cent under-enumeration	10.6	12.4	11.1	12.6	11.3	12.8
Life expectancy/birth	68.0	70.1	47.6	49.5	37.5	39.3
Life expectancy/age 5	65.8	67.9	54.0	55.6	48.1	49.3
SET 2	HYPOTHESIS 1		HYPOTHESIS 2		HYPOTHESIS 3	
	MALES	FEMALES	MALES	FEMALES	MALES	FEMALES
Growth rate (%/yr.)	3.4	3.4	2.8	2.8	2.4	2.4
Mortality level[a]	21.3	20.3	12.8	12.2	8.9	8.2
Birth rate/1,000	40.1	40.0	45.6	45.2	50.3	49.5
Death rate/1,000	6.1	6.0	17.6	17.2	26.3	25.5
TOTAL POPULATION	6,140.0	6,200.0	6,170.0	6,220.0	6,180.0	6,230.0
Per cent under-enumeration	9.5	11.0	10.0	11.2	10.2	11.2
Life expectancy/birth	66.9	68.1	46.7	47.9	37.0	38.1
Life expectancy/age 5	65.0	66.6	53.4	54.6	47.8	48.6
SET 3	HYPOTHESIS 1		HYPOTHESIS 2		HYPOTHESIS 3	
	MALES	FEMALES	MALES	FEMALES	MALES	FEMALES
Growth rate (%/yr.)	3.4	3.4	2.8	2.8	2.4	2.4
Mortality level[a]	21.6	20.5	13.1	12.4	9.0	8.4
Birth rate/1,000	39.8	39.8	45.2	44.7	49.8	49.0
Death rate/1,000	5.8	5.8	17.2	16.7	25.8	25.0
TOTAL POPULATION	6,280.0	6,350.0	6,310.0	6,360.0	6,330.0	6,370.0
Per cent under-enumeration	11.6	13.0	12.0	13.2	12.3	13.3
Life expectancy/birth	67.6	68.9	47.2	48.5	37.4	38.5
Life expectancy/age 5	65.5	67.0	53.8	55.0	48.0	48.8

[a]The mortality level refers to the chosen model stable population among those of the West family of models.

Notes: The sets refer to age distribution adjustments (see section 4.3) with Set 1 being preferred. The hypotheses refer to estimates of growth (see Table 8) with Hypotheses 2 and 3 being preferred.

Similar calculations are given for the total population of Morocco in 1960 (Table 21). These naturally are very close to the estimates for Muslems. As could be expected, birth rates are slightly lower than those of only the Muslem population; but death rates turn out to be slightly higher. Possibly the estimates of out-migration were conservative so that the migrants that had not been accounted for now appear as deaths. In any case, stable population conditions do not apply to Israelites and Foreigners.

TABLE 21. VITAL RATES, AS CALCULATED THROUGH STABLE POPULATION TECHNIQUES, TOTAL POPULATION OF MOROCCO, 1960 (Set 1 of age distribution adjustments)

	HYPOTHESIS 1		HYPOTHESIS 2		HYPOTHESIS 3	
	MALES	FEMALES	MALES	FEMALES	MALES	FEMALES
Growth rate (%/yr.)	3.3	3.3	2.7	2.7	2.3	2.3
Mortality level[a]	21.6	20.7	13.0	12.5	9.0	8.5
Birth rate/1,000	39.0	38.7	44.3	43.7	48.8	47.7
Death rate/1,000	6.0	5.7	17.3	16.7	25.8	24.7

[a]The mortality level refers to the chosen model stable population among those of the West family of models.

Note: The hypotheses refer to the estimates of growth (see Table 8), with Hypotheses 2 and 3 being preferred.

A series of other measures can be calculated from the chosen models. A few of the more relevant parameters are given (Table 22). The Gross Reproduction Rate (GRR) is probably the most interesting of these. This rate depends, however, on the shape of the fertility schedule and especially on the age of highest fertility among females ($\bar{m}$). The Multiple-Purpose Survey (Maroc, S.C.S., 1964: 71) establishes this modal fertility at ages 25-29 in rural areas and thus GRR (27) should be

TABLE 22. OTHER POPULATION PARAMETERS AS CALCULATED THROUGH STABLE POPULATION TECHNIQUES, MOROCCO MUSLEMS AND TOTAL POPULATION, 1960
(Set 1 of age distribution adjustments)

	HYPOTHESIS 1		HYPOTHESIS 2		HYPOTHESIS 3	
	MALES	FEMALES	MALES	FEMALES	MALES	FEMALES
MOROCCO MUSLEMS						
Mortality level	21.80	21.10	13.20	12.80	9.10	8.70
GRR (27)[a]	2.60	2.59	2.88	2.85	3.13	3.10
GRR (29)[b]	2.79	2.77	3.08	3.05	3.34	3.31
Average age	22.40	22.70	22.00	22.50	21.80	22.20
Average age at death	43.80	45.20	23.00	23.80	18.90	19.50
Average age at death over age 5	59.70	61.70	45.70	45.90	41.90	41.70
TOTAL POPULATION						
Mortality level	21.60	20.70	13.00	12.50	9.00	8.50
GRR (27)[a]	2.55	2.55	2.82	2.82	3.07	3.05
GRR (29)[b]	2.73	2.73	3.02	3.01	3.27	3.26
Average age	22.60	22.90	22.30	22.70	22.10	22.50
Average age at death	43.80	44.10	23.50	23.80	19.30	19.90
Average age at death over age 5	59.60	60.90	45.90	45.80	42.30	42.00

[a]Gross Reproduction Rate as estimated using age 27 (females) as age of highest fertility.

[b]Gross Reproduction Rate as estimated using age 29 (females) as age of highest fertility.

Note: The hypotheses refer to estimates of growth (see Table 8), with Hypotheses 2 and 3 being preferred.

preferred; this rate would be 2.9 for both sexes together (Muslems, Hypothesis 2).

Since the various parameters of a stable population can be identified on the basis of only one sex, an interesting comparison can be made by deriving estimates for each sex both directly (by identifying the appropriate model through the proportions at the various ages) and indirectly (by using estimates of one sex in conjunction with the sex ratio at birth and the sex ratio of the population to compute estimates for the other sex). These calculations have been made on the basis of both 105 and 102 as the masculinity ratios at birth (Table 23). It is encouraging that there is remarkable agreement between these two relatively independent approaches.[35] There is even more agreement when 102 is used as the sex ratio at birth, thus giving some evidence to this being the appropriate ratio.

We have continuously used the proportion (0-9)/25+ to identify the appropriate stable population. Such a measure has strengths and weaknesses which should be identified. Among the principal advantages are those of being able to neglect the troublesome ages and of permitting an estimation of under-enumeration. A disadvantage is that of having to establish two "firm rims" across which there either must be negligible misreporting or control must be made for such as might be occurring. The generally preferred alternative of using proportions to given ages requires only one such "cutting line." Also, the use of proportions to

[35]Coale and Demeny (U.N., 1967: Population Study Number 42: 51) suggest that these two approaches are more independent than estimates derived from the same sex by stable population in comparison to census survival, since this latter combination is but two sets of inferences from the same basic data.

TABLE 23. BIRTH RATES CALCULATED DIRECTLY THROUGH STABLE POPULATION AND CALCULATED FROM THE OTHER SEX, MOROCCO MUSLEMS, 1960 (Using 105 and 102 as sex ratios at birth)

	HYPOTHESIS 1		HYPOTHESIS 2		HYPOTHESIS 3	
	MALES	FEMALES	MALES	FEMALES	MALES	FEMALES
SET 1						
Calculated directly	39.7	39.3	45.0	44.0	49.6	48.3
Calculated indirectly (105)	41.1	38.0	46.0	43.1	50.5	47.5
Calculated indirectly (102)	40.0	39.1	44.7	44.3	49.0	48.9
SET 2						
Calculated directly	40.1	40.0	45.6	45.2	50.3	49.5
Calculated indirectly (105)	41.8	38.4	47.2	43.7	51.7	48.2
Calculated indirectly (102)	40.6	39.5	45.9	44.9	50.2	49.6
SET 3						
Calculated directly	39.8	39.8	45.2	44.7	49.8	49.0
Calculated indirectly (105)	41.6	38.1	46.7	43.3	51.2	47.7
Calculated indirectly (102)	40.4	39.2	45.4	44.5	49.7	49.1

Note: All rates per thousand population.
The sets refer to age distribution adjustments (see section 4.3), with Set 1 being preferred.
The hypotheses refer to estimates of growth (see Table 8), with Hypotheses 2 and 3 being preferred.

given ages enables the researcher to derive estimates based on a series of such proportions and to subsequently choose the median among these (though the proportion to age 35 is generally preferred). Since, for Morocco Muslems, the male age distribution presents considerable regularity after age 25, additional estimates were obtained using the proportions (0-9)/30+, (0-9)/35+, and (0-9)/40+ (Table 24). These estimates do not

vary greatly from those presented earlier. The estimates using these alternative proportions, however, do imply slightly lower vital rates with slightly higher under-enumeration.

TABLE 24. ALTERNATIVE STABLE POPULATION ESTIMATES WITH GROWTH RATE 2.8 (HYPOTHESIS 2) AND VARIOUS AGE DISTRIBUTION MEASURES, MOROCCO MUSLEMS, MALES, 1960

MEASURE USED	(0-9)/25+	(0-9)/30+	(0-9)/35+	(0-9)/40+
Mortality level	13.2	14.3	14.8	15.3
Birth rate/1,000	45.0	43.1	42.3	41.6
Death rate/1,000	17.0	15.1	14.3	13.6
Per cent under-enumeration	11.1	11.9	12.4	12.9

It has been remarked that stable population estimates can be in error due to choosing an inappropriate family of corresponding model life tables. In order to establish the possible extent of this error, estimates were derived on the basis of the three other families (Table 25).

TABLE 25. COMPARISON AMONG ESTIMATES DERIVED FROM THE FOUR FAMILIES OF MODEL STABLE POPULATIONS, MOROCCO MUSLEMS, FEMALES, 1960 (by 1,000s)

FAMILY	WEST	NORTH	SOUTH	EAST
Mortality level	12.8	13.3	11.8	11.5
Birth rate/1,000	44.0	43.5	46.8	47.0
Death rate/1,000	16.0	15.5	18.8	19.0
TOTAL POPULATION	6,320.0	6,280.0	6,280.0	6,310.0
Per cent under-enumeration	12.6	12.0	12.0	12.5
Life expectancy at birth	49.5	50.8	47.0	46.3
Life expectancy at age five	55.6	56.3	56.8	55.5

Note: These estimates were derived from the proportion 0-9 (31.9%) that corresponds to the chosen West model at mortality level 12.8 with r = 2.8 (Hypothesis 2, Set 1).

These estimates do not differ greatly from those of the West model: vital rates are slightly lower with the North pattern of mortality and slightly higher with the South and East patterns. There is strong agreement among families on the life expectancy at age five; this could be expected since differences in patterns of mortality refer especially to the younger ages.

4.4 Adjustments for Quasi-stability

Coale and Demeny (U.N., 1967: Population Study Number 42: 25-28) have devised formulae and accompanying tables whereby stable population estimates can be corrected for quasi-stability. The procedure is based on the rate of mortality change which will be derived here from the absolute change in the rate of growth of the population and the time span of this change. The formula used follows:

$$K = 17.8 \times \frac{\Delta r}{\Delta t}$$

where K = Parameter indicating the rate of mortality change expressed in terms of the equivalent proportionate annual increase in fertility insofar as the age distribution effects are concerned;

Δr = Absolute change in the rate of growth;

Δt = Number of years that have elapsed while the change in the rate of growth took place.

A table is provided (U.N., 1967: Population Study Number 42: 119) whereby this value of 'K' can be used along with the time span in order to adjust the vital rates.[36]

[36] For a detailed example of the calculations involved in the application of this technique, see Coale and Demeny (U.N., 1967: Population Study Number 42: 68-72).

It is somewhat difficult to establish the growth rate in Morocco previous to the mortality decline (see Table 6). The growth rate in the period 1926-1931 is probably the better estimate of previous stability: growth in the periods 1921-1926 and 1931-1936 would be exaggerated due to the superiority of the second enumeration over the first in each case.[37] This 1926-1931 growth of 1.6% per year is probably still an over-estimate since the growth for 1936-1960, between two censuses of reputedly superior quality, is only 2.1% per year. Two assumptions were therefore made relevant to the 1926-1931 growth:

Assumption 1: Considerable improvement in coverage between the two censuses; r = 1.0.

Assumption 2: No improvement in coverage; r = 1.6.

These, when matched with the three hypotheses of 1952-1960 growth, yield six quasi-stable estimates (Table 26). We note that there is virtually no difference between the two assumptions: vital rates are 0.4 per thousand higher in Assumption 2 than in Assumption 1. Also (comparing with Table 20, Set 1), the adjustments do not greatly change the vital rates; these are, in fact, lowered by approximately 1.0 per thousand when quasi-stability is taken into consideration. What is more surprising is that, contrary to previous expectations, vital rates are lowered by this adjustment. It can be seen by the table used (U.N., 1967: Population Study Number 42: 119) that while adjustments for quasi-stability generally increase vital rates, those estimates that are based on the proportion to age 5 or to age 10 are instead depressed when quasi-stability is taken into consideration.

---

[37]Bouisri and Pradel DeLamaze (1971) suggest that the growth rate for Algeria was constant until around 1920.

TABLE 26. VITAL RATES ADJUSTED FOR QUASI-STABILITY, MOROCCO MUSLEMS, 1960 (Set 1 of age distribution adjustments)

	HYPOTHESIS 1		HYPOTHESIS 2		HYPOTHESIS 3	
	MALES	FEMALES	MALES	FEMALES	MALES	FEMALES
ASSUMPTION 1: Earlier stable growth rate of 1.0% per year						
Stable						
Birth rate/1,000	39.7	39.3	45.0	44.0	49.6	48.3
Quasi-stable						
Birth rate/1,000	38.3	37.7	43.3	42.7	47.9	47.2
Death rate/1,000	4.3	3.7	15.3	14.7	23.9	23.2
Mortality level	23.3		13.6		9.2	
Life expectancy at birth	71.9	75.7	48.6	51.5	37.7	40.4
ASSUMPTION 2: Earlier stable growth rate of 1.6% per year						
Stable						
Birth rate/1,000	39.7	39.3	45.0	44.0	49.6	48.3
Quasi-stable						
Birth rate/1,000	38.7	38.1	43.7	43.1	48.3	47.6
Death rate/1,000	4.7	4.1	15.7	15.1	24.3	23.6
Mortality level	22.6		13.4		9.0	
Life expectancy at birth	70.2	74.1	48.0	50.9	37.2	39.9

Note: These calculations are based on the adjustments required when the proportion to age ten is used as the basis of the stable population estimate. The masculinity ratio at birth of 102 was used to derive estimates for males. The hypotheses refer to estimates of growth (see Table 8) with Hypotheses 2 and 3 being preferred.

4.5 Estimates Derived by other Researchers

To this author's knowledge, the estimates presented here are the first that have been obtained through stable population methods for the Maghrebian countries. Several other authors have used various other techniques for a similar purpose. Some of the estimates that have been made for Tunisia, Algeria, and Morocco are presented in Table 27.

TABLE 27. ESTIMATES OF VITAL RATES, LIFE EXPECTANCY, GROSS REPRODUCTION RATES, AND INFANT MORTALITY AS DERIVED BY OTHER RESEARCHERS FOR TUNISIA, ALGERIA, AND MOROCCO

AUTHOR	TIME PERIOD	BIRTH RATE	DEATH RATE	GROWTH (%/yr.) NATURAL	GROWTH (%/yr.) INTER-CENSUS	LIFE EXPECT-ANCY	GRR	INFANT MOR-TALITY
TUNISIA								
Picquet (1969)	1946-56				2.0			
	1956-66				2.6			
Marcoux (1971)	1956-62	45.8	19.8	2.6				
	1966-71					52.5		
Vallin (1970)	1968	41.0	14.0	2.7	2.6			
(1971) Preliminary results of Enquète Nationale Demographique	1968	42.0	12.5	2.6-2.9				
Benyoussef (1967: 352, 358-59)	1956-59	47.0	26.0			50.0		
ALGERIA								
Bouisri and Pradel DeLamaze (1970)	1966	50.0	18.0	3.2-3.5		55.0		
Vallin (1970)	1968	46.0	15.0	3.1	3.0			
Benyoussef (1967: 352, 358-59)	1956	44.0						
	1961		15.8			50.8		
MOROCCO								
Vallin (1970)	1968	47.0	18.0	2.9	3.1			

TABLE 27. Continued.

AUTHOR	TIME PERIOD	BIRTH RATE	DEATH RATE	GROWTH (%/yr.) NATURAL	GROWTH (%/yr.) INTER-CENSUS	LIFE EXPECT-ANCY	GRR	INFANT MOR-TALITY
MOROCCO (continued)								
Benyoussef (1967: 55-62)[a]								
Range of estimates	1960	47.0-51.0	17.0-25.0			40.0-50.0	2.25-2.59	
Retained as most probable	1960	50.0	20.0	3.0		46.0		
Noin (1970: I: 40)	1960-65				2.8-2.9[b]			
Berrada (1970)	1960	50.0				47.5	3.0	
Brown (1968)	1960	50.0	18.0	3.2				
Maroc, S.C.S. (1965: I: 47-49)	1960	52.0-53.0[c]	24.0-25.0[d]			40.0-45.0[d]		
Maroc, Multiple-Purpose Survey, (S.C.S., 1964: 69-81)	1961-63							
Rural areas		45.6	20.0	2.53				170
Plains and hills		45.5	18.0	2.77				158
Arid and mountainous regions		45.7	24.0	2.20				186
Urban areas		47.2	15.0	3.24				100
Total country		46.1	19.0	2.74				149

[a]Using Thompson index.

[b]After considering under-enumeration.

[c]Using reverse survival with age group 0-4.

[d]Comparing 1952 and 1960 data.

The results of the Multiple-Purpose Survey are of particular interest; as can be seen from the table, they give evidence of considerable regional differences in the death rates and consequently in the growth rates.

4.6 Discussion, Reliability, and Final Estimates

Generally, in spite of (or because of) the rather wide dispersion, results of the census survival and stable population analyses presented herein agree with those derived by other authors. It would appear that the most problematic factor as regards our estimates is that of the growth rate with its consequent effects, especially on the estimates of the death rate. This author would argue that the growth rates used by such researchers as Benyoussef (1967) and Brown (1968) are exaggerated.

There are two serious disagreements among the estimates that have been made in this analysis: between the male and female outcomes of the census survival methods and between Hypotheses 2 and 3 ($r = 2.8$ and 2.4) in the stable population analysis. It is interesting that two of these (female census survival and stable population with $r = 2.4$) place the death rate per thousand around 25 to 28, while the other two place it around 17 to 18. Beyond this, there is remarkable coherence among estimates derived through stable population. Having been able to discard Hypothesis 1, the birth rate is well established between 45 and 49 for both sexes. There is little divergence among estimates based on the three sets of age distribution adjustments. Even more remarkable is the agreement between estimates derived independently from each sex (Table 23). Also, there is considerable agreement among parameters derived through the different families of stable populations (Table 25) as well as among those obtained through different measures of the age distribution (Table 24).

This, in conjunction with the observation that census survival methods presented internally contradictory results and, also, with the fact that more work was done on adjustments relevant to the stable population analysis, suggests that estimates derived from the latter should be preferred. We do not feel, however, that there is sufficient evidence to choose among the two growth rates (2.8 and 2.4) and therefore both series of estimates will be retained. Taken together, these two series actually cover fairly well the range of estimates that were obtained by the census survival method. We would tend to disregard also the adjustments for quasi-stability. First, these adjustments are rather minor (a difference of some 1.0 per thousand on the vital rates). Second, they are depressing vital rates while other considerations suggest that such a reduction is not valid. It will be recalled that only omissions at age zero were considered for age groups 0-9. However, it is highly possible that other omissions before age ten are occurring more often than omissions over age twenty-five and this would have the effect of under-estimating fertility (the base of the pyramid having been reduced). To counter-balance for this probable deficiency in estimates, the depressing effect of adjustments for quasi-stability will therefore be neglected.

The estimates retained for Morocco Muslems are given in Table 28. The author would tend to prefer the lower vital rates (derived from r = 2.8, Hypothesis 2, Set 1) for reasons previously considered. An argument could, however, be made in favor of a lower growth rate (i.e., large dificiencies in coverage in 1950-1952) and thus something like the mean of these figures may be preferable. But, given the inadequacy of the data, an exact choice among these alternatives is really not warranted. It is encouraging that the results of the Multiple-Purpose

TABLE 28. FINAL ESTIMATES, MOROCCO MUSLEMS, 1960 (by 1,000s)

	MALES	FEMALES
Growth rate (%/yr.)	2.4 - 2.8	2.4 - 2.8
Birth rate/1,000	45.0 - 50.0	44.0 - 48.0
Death rate/1,000	17.0 - 26.0	16.0 - 24.0
Life expectancy at birth	38.0 - 48.0	39.0 - 50.0
Life expectancy at age five	48.0 - 54.0	49.0 - 56.0
Gross Reproduction Rate	2.9 - 3.1	2.9 - 3.1
Average age	22.0	22.0 - 23.0
Average age at death	19.0 - 23.0	20.0 - 24.0
Average age at deaths over age five	42.0 - 46.0	42.0 - 46.0
Percent under-enumeration	11.1 - 11.3	12.6 - 12.8
TOTAL POPULATION	6,240.0 - 6,260.0	6,320.0 - 6,330.0

Source: See Tables 20 and 22 (Set 1, Hypotheses 2 and 3).

Survey (Table 27) are in general agreement with these final estimates. The super-imposition of the census results and final estimates (Hypothesis 2, Set 1) gives a good visual representation of the under-enumeration that has been uncovered (Figure 16). Again, this assumed under-enumeration may be partly mistaken for some real shortages in the age groups 10-24, but real shortages certainly cannot provide a full explanation of the deficiencies.

4.7 Methodological Significance and Conclusions

The ground that has been covered can be better appreciated by a comparison with the estimates that had first been derived on the basis of unadjusted data (Table 29). This involved a strict application of the

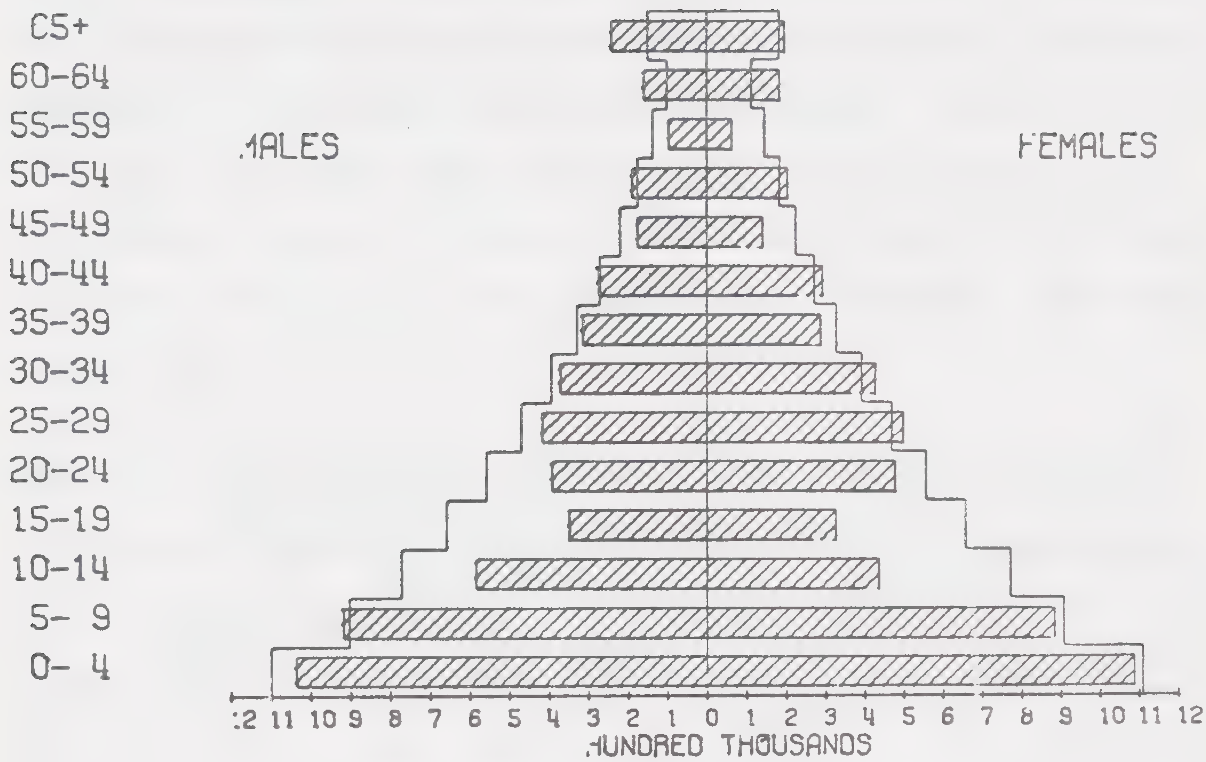


FIGURE 16. MOROCCO MUSLEMS 1960

CENSUS RESULTS AND FINAL ESTIMATES

POPULATION RESEARCH LABORATORY
UNIVERSITY OF ALBERTA

Coale-Demeny methods (U.N., 1967: Population Study Number 42) whereby the mortality levels implied by the proportions up to various ages are calculated with their associated vital rates. The growth rate used (3.0% per year) approximates that which a researcher would arrive at if differential under-enumeration among censuses was not considered. The various measures of the unadjusted age distribution roam over a range of mortality levels which almost span the whole range of human experience. Both the preferred proportion (to age 35) and the median mortality level among the first nine age groups (0-39 for males, 0-34 for females) give totally absurd results.

TABLE 29. STABLE POPULATION ESTIMATES THROUGH PROPORTIONS TO VARIOUS AGES, MOROCCO MUSLEMS, 1960 (Based on the age distribution that has been adjusted only for migration)

AGES	MALES				FEMALES			
	PROPORTION OF TOTAL	MORTALITY LEVEL	BIRTH RATE	DEATH RATE	PROPORTION OF TOTAL	MORTALITY LEVEL	BIRTH RATE	DEATH RATE
0-4	18.70	12.14	49.0	19.0	19.69	8.98	54.1	24.1
0-9	35.27	9.26	55.9	25.9	35.69	8.00	56.8	26.8
0-14	45.81	13.23	46.8	16.8	43.62	16.41	40.6	10.6
0-19	52.11	21.76	36.2	6.2	49.56	24+	33.8	3.8
0-24	59.23	24.00	34.5	4.5	58.24	24+	33.8	3.8
0-29	66.81	24.00	34.5	4.5	67.30	21.74	35.2	5.2
0-34	73.58	23.45	34.9	4.9	75.06	18.92	37.8	7.8
0-39	79.29	23.0	35.2	5.2	80.28	19.13	37.5	7.5
0-44	84.28	22.3	35.7	5.7	85.59	17.23	39.6	9.6

Note: The West family of model stable populations was used with the growth rate of 3.0% per year.

This is strong evidence of the need to study possible age- and sex-selective under-enumeration (along with misreporting) before proceeding to make estimates through stable population analysis. Such deficiencies in the age distribution can be fairly well identified by studying the age-specific sex ratios, the age ratios, the census survival rates, and the single-year age distributions. These adjustments to the age distribution are always somewhat subjective and they destroy some of the straightforwardness of the Coale-Demeny analysis, but they do not require the heroic assumption of no age- and sex-selective under-enumeration; and they can well lead to more adequate estimates. Such considerations can also lead the researcher to decide which measures of the age distribution are trustworthy. The measure chosen in this study, (0-9)/25+, though it requires that two "cutting points" be established across which misreporting must be either negligible or accounted for, presents the strong advantage of being able to neglect the often poorly reported ages 10-24. This procedure also enables the researcher to estimate the under-enumeration to which his data are subject. The subsequent adjustments for the total population size may occasionally be as important a result of the estimation procedure as that of the vital rates themselves.

The study is also another demonstration of the usefulness of stable population methods in establishing various population parameters on the basis of inadequate or incomplete data. As Bourgeois-Pichat (1958) has emphasized, these procedures should never be used mechanically and each case has its own particular method of analysis. Som (1969) also warns that Coale-Demeny methods have been known to produce absurd results in the hands of the inexperienced. This contests the claim made by Coale and Demeny (U.N., 1967: Population Study Number 42: 2) that all the

methods can be employed by persons with no more than a one-year special course in demography. Though in the long run the basic data must be improved so that direct counts of fertility and mortality become available, in the meantime such techniques as used here can provide useful substitutes. As has been noted by other authors and demonstrated once again, these methods are especially good for estimating fertility. In regard to mortality, we would have a similar observation to that made by Brass, et al., (1968), that such estimates are the least trustworthy of the results produced. Also, these procedures should, if at all possible, be accompanied by other techniques that estimate the same parameters from a different basis. Census survival techniques provide a poor confirmation since they essentially involve inferences from the same basic data. Of much more relevance are estimates based on the fertility and mortality experience of a sample of the population.

In the end, it is hoped that an analysis of 1971 census data will help to confirm or disprove some of the results of this study (especially as regards under-enumeration) and that the results of this recent census, in conjunction with other sources of sample data that are being developed in Morocco, will warrant a reduction of both the uncertainty and the range of estimates obtained thus far.

SELECTED BIBLIOGRAPHY

Abdel-Aty, S. H.
1961 "Life Table Functions for Egypt Based on Model Life Table and Quasi-stable Population Theory." Milbank Memorial Fund Quarterly. 39 (2) April: 351-77.

Bahri, Ahmed and Dellouci, B.
1971 "L'emploi en Algérie à travers le Recensement de 1966." Population. 26 (Numéro Spécial) Mars: 13-24.

Beaujot, Roderic P. and Elamrani-Jamal, Abdessetar.
1972 "Direct Observation as a Mode of Census Evaluation: Observations Directes sur l'Execution du Recensement/Census Observations by Senior Personnel." Paper prepared for presentation at the session on "Methodological Issues in Moroccan Demography." Annual Meetings of the Population Association of America. Toronto, Canada. April 13-15.

Benyoussef, Amor.
1967 Population du Maghreb et Communauté Economique à Quatre, Esquisse d'une Théorie Démographique de l'Intégration. Paris: Société d'Edition et d'Enseignement Supérieur.

Berrada, Abdallah.
1970 "Démographie Marocaine, Dimensions, Implications." Paris. Dissertation.

Bouisri, Abdellaziz and Pradel DeLamaze, François.
1971 "La Population d'Algérie d'après le Recensement de 1966." Population. 26 (Numéro Spécial) Mars: 25-46.

Bourgeois-Pichat, Jean.
1958 "Utilisation de la Notion de Population Stable pour Mesurer la Mortalité et la Fécondité des Populations des Pays Sous-developpés." Bulletin de l'Institut International de Statistiques. 36 (2): 94-121.

________.
1971 "Stable, Semi-stable Populations and Growth Potential." Population Studies. 25 (2) July: 235-54.

Brass, William; Coale, Ansley J.; Demeny, Paul; Heisel, Don F.; Lorimer, Frank; Romaniuk, Anatole and Walle, Etienne van de.
1968 The Demography of Tropical Africa. Princeton, New Jersey: Princeton University Press.

Brown, George F.
1968 "Moroccan Family Planning Program--Progress and Problems." Demography. 5 (2): 627-31.

Coale, Ansley J.
1955 "The Population of the U.S. Classified by Age, Sex, and Color--A Re-vision of Census Figures." Journal of the American Statistical Association. 50: 16-54.

________.
1956 "The Effects of Changes in Mortality and Fertility on Age Composition." Milbank Memorial Fund Quarterly. 34 (1) January: 79-114.

________.
1957 "How the Age Distribution of a Human Population is Determined." Cold Spring Harbor Symposia on Quantitative Biology. 22: 83-89.

________.
1963 "Estimates of Various Demographic Measures through the Quasi-stable Age Distribution." Emerging Techniques in Population Research. Milbank Memorial Fund (eds.).: 175-93.

________.
1968 "Convergence of a Human Population to a Stable Form" Journal of the American Statistical Association. 63 (322) June: 395-435.

________. and Demeny, Paul.
1966 Regional Model Life Tables and Stable Populations. Princeton, New Jersey: Princeton University Press.

________. and Hoover, Edgar M.
1958 Population Growth and Economic Development in Low-income Countries. Princeton, New Jersey: Princetone University Press.

________. and Zelnik, M.
1963 New Estimates of Fertility and Population in the U.S. Princeton, New Jersey: Princeton University Press.

Demeny, Paul.
1965 "Estimates of Vital Rates for Populations in the Process of Destabilization." Demography. 2: 516-30.

________. and Shorter, Frederic C.
1968 "Estimating Turkish Mortality, Fertility and Age Structure--Application of Some New Techniques." Publication No. 218, Faculty of Economics. Istanbul: University of Istanbul.

Devillars, Pierre.
1954 "L'immigration Marocaine en France." Cahiers Nord-Africains. 37: 62 pp.

Dublin, L. I. and Lotka, A. J.
1925 "On the True Rate of Natural Increase as Exemplified by the Population of the U.S., 1920." Journal of the American Statistical Association. 20: 305-39.

Esprit.
1966 "Etrangers en France." Numéro Spécial, 4 (April).

Euler, Leonhard.
1760 "Recherches Générales sur la Mortalité et la Multiplication du Genre Humain." Histoire de l'Académie Royale des Sciences et Belles-Lettres. Vol. XVI. Berlin.: 144-68.

France, Institut National de Statistiques et d'Etudes Economiques (INSEE).
1966 Annuaire Statistique de la France, Résumé Rétrospectif. Vol. 72.

________.
1967 Recensement Général de la Population de 1962--Résultats du Dépouillement Exhausif--Récapitulations pour la France Entière. Paris: Imprimerie Nationale.

________.
1969 Movement de la Population, Statistiques Annuelles, 1960-61-62. Book 1. Paris: Imprimerie Nationale.

Gaisie, S. K.
1969 "Estimation of Vital Rates for Ghana." Population Studies. 23 (1) March: 21-42.

Ghansah, Daniel K.
1969 "The Volume and Structure of International Migration in Africa." International Population Conference. Vol. IV. London: International Union for the Scientific Study of Population.: 2573-82.

Graunt, John.
1662 Natural and Political Observations. . . Made upon the Bills of Mortality. Dedications dated "25 January 1661-2."

Halley, Edmond.
1693 "An Estimate of the Degrees of the Mortality of Mankind, Drawn from Curious Tables of the Births and Funerals at the City of Breslaw. . . ." Philosophical Transactions of the Royal Society of London. Vol. XVII: 596-610.

International Migration Digest.
1965 "African Migrant Workers in Europe." II (1) Spring: 97-102.

Israel, Central Bureau of Statistics.
1966
1969 Statistical Abstract of Israel. Jerusalem.

Keyfitz, Nathan.
1965 "Age Distribution as a Challenge to Development." American Journal of Sociology. 70 (6) May: 659-68.

________.
1966 "Reply to van de Walle." American Journal of Sociology. 71 (5): 556-57.

________.
1968 Introduction to the Mathematics of Population. Reading, Massachusetts: Addison-Wesley.

Kim, Yun.
1965 "Some Demographic Measurements for Korea Based on the Quasi-stable Population Theory." Demography. 2: 567-78.

Krotki, Karol J.
1963 "Population Size, Growth, and Age Distribution: Fourth Release from the 1961 Census of Pakistan." The Pakistan Development Review. 3 (2): 279-305.

________.
1969 "The Treatment of Age Errors in Population Data in the U.N. Proposed Application of Stable Population Methods." Paper prepared for the session on "Errors in Data Sources." Annual Meetings, Population Association of America. Atlantic City, New Jersey. Mimeographed.

________. and Thakur, H. N.
1971 "Estimates of Population Size and Growth from the 1952-54 and 1961 Censuses of the Kingdom of Nepal." Population Studies. 25 (1): 89-103.

LeBras, Hervé.
1969 "Retour d'une Population à l'Etat Stable après une Catastrophe." Population. 24 (5) septembre-octobre: 862-96.

________.
1971 "Eléments pour une Théorie des Populations Instables." Population. 26 (3) mai-juin: 525-62.

Ledjri, Mohamed Naceur.
1969 "Le Recensement Général de la Population (Mai 1966)." Revue Tunisienne des Sciences Sociales. 17-18 juin-septembre: 127-70.

Le Petit Marocain.
1971 "Recensement: La Population s'élève à 15,379,259 Habitants." le 2 novembre.

Lopez, Alvaro.
1961 Problems in Stable Population Theory. Princeton, New Jersey: Office of Population Research.

Lopez, Alvaro.
1967 "Asymptotic Properties of a Human Age Distribution under a Continuous Net Maternity Function." Demography. 4: 680-87.

Lorimer, Frank.
1959 "The Development of Demography." The Study of Population. Philip M. Hauser and Otis Dudley Duncan (eds.). Chicago: University of Chicago Press.: 124-79.

Lotka, Alfred J.
1907 "Studies on the Mode of Growth of Material Aggregates." American Journal of Science. XXIV, 141: 199-216.

________.
1928 "The Progeny of a Population Element." American Journal of Hygiene. 8 (6): 875-901.

________.
1934-1939 Théorie Analytique des Associations Biologiques. Two Volumes. Paris: Hermann et Cie.

________.
1956 Elements of Mathematical Biology. New York: Dover.

Maghreb Information.
1971 "L'incertitude des Chiffres du Recensement Exige l'Apport de Nouvelles Précisions." No. 530, Nouvelle Série, le 11 novembre: 1-2.

Marcoux, Alain.
1971 "La Croissance de la Population de la Tunisie, Passé Récent et Perspéctives." Population. 26 (Numéro Spécial) Mars: 105-24.

Maroc, Service du Travail et des Questions Sociales.
1936 Résultats Statistiques du Recensement de la Population de la Zone Française de l'Empire Chérifien. Rabat.

________., Service des Statistiques.
1947 Dénombrement General de la Population de la Zone Française de l'Empire Chérifien Effectué le mars 1947. Four Volumes.

________., Service Central des Statistiques (S.C.S.).
1952 Recensement Général de la Population de la Zone Française de l'Empire Chérifien. Four Volumes.

________.
1961 Consomation et Dépenses des Ménages Marocains Musulmans, Résultats de l'Enquète 1959-60. Rabat.

Maroc, Service Central des Statistiques
(S.C.S.).
1964 Résultats de l'Enquête à Objectifs Multiples 1961-1963. (Multiple-Purpose Survey). Rabat: Imprimar-Rabat.

________.
1965 Résultats du Recensement de 1960. Four Volumes. Rabat: Imprimar-Rabat.

________.
Yearly
Annuaire Statistique du Maroc. Rabat: Imprimar-Rabat.

McFarland, D. D.
1969 "On the Theory of Stable Populations." Demography. 6 (3): 301-22.

Noin, Daniel.
1970 La Population Rurale du Maroc. Two Volumes. Paris: Presses Universitaires de France.

Opinion.
1971 "Ils Recrutent Clandestinement de Ouvriers Marocains pour l'Etranger." le 2 mai.

________.
1971 "Plus de 30,000 Ouvriers Marocains Ont Quitte leur Pays pour l'Etranger." le 2 mai.

Paskoff, Roland.
1957 "La Region de Berguent." Cahiers d'Outre Mer. 10: 34-64.

Picquet, Michel.
1969 "Etude de l'Evolution de la Structure par Age de la Population Tunisienne à Partir des Pyramides d'Ages." Revue Tunisienne de Sciences Sociales. 17-18: 177-213.

Population.
1971 "Le Maghreb." Numéro Spécial, 26, mars.

Preston, Samuel H.
1970 "Empirical Analysis of the Contribution of Age Composition to Population Growth." Demography. 7 (4) November: 417-32.

Prevost, Guy.
1969 "Des Chiffres et des Hommes: Les Etrangers en France." Hommes et Migrations. 113: 8-45.

Prothero, R. Mansell.
1965 Migrants and Malaria in Africa. Pittsburgh, Pennsylvania: University of Pittsburgh Press.

Romaniuk, A.
1967 "Estimation of the Birth Rate for the Congo through Non-conventional Techniques." Demography. 4 (2): 688-701.

________. and Piché, V.
1971 "Natality Estimates for the Canadian Indians by Stable Population Methods, 1900-1969." Paper presented at the Sixth Annual Meeting of the Canadian Sociology and Anthropology Association. St. John's, Newfoundland: Memorial University. June 6-9.

Scott, S. and Sabagh, G.
1970 "The Historical Calendar as a Method of Estimating Age: The Experience of the Moroccan Multiple-Purpose Sample Survey of 1961-63." Population Studies. 24 (2) March: 93-109.

Seklani, M.
1960 "La Fecondité dans les Pays Arabes: Données Numériques, Attitudes et Comportements." Population. 15 (5) octobre-decembre: 831-56.

Sharpe, F. R. and Lotka, A. J.
1911 "A Problem in Age-distribution." Philosophical Magazine. Series 6, XXI: 435-37.

Som, Ranjan K.
1969 "Review of the Demography of Tropical Africa." American Sociological Review. 34 (5) October: 808-09.

United Nations, Department of Economic and Social Affairs.
Yearly
Demographic Yearbook.

________.
1952 "Accuracy Tests for Census Age Distribution Tabulated in Five-year and Ten-year Groups." Population Bulletin, Number 2.: 59-79.

________.
1954 "The Cause of the Aging of Populations: Declining Mortality or Declining Fertility?" Population Bulletin of the U.N., Number 4. Population Division: 30-38.

________.
1955 "Age and Sex Patterns of Mortality. Model Life Tables for Under-developed Countries." United Nations Population Study, Number 22.

________.
1956 "Methods for Population Projections by Sex and Age." United Nations Population Study, Number 25. Manual III.

United Nations, Department of Economic and Social Affairs.
1967 "Methods of Estimating Basic Demographic Measures from Incomplete Data." United Nations Population Study, Number 42. Manual IV.

________.
1968 "The Concept of a Stable Population. Application to the Study of Populations of Countries with Incomplete Demographic Statistics." United Nations Population Study, Number 39.

Vallin, Jacques.
1970 "Les Populations de l'Afrique au Nord du Sahara." Population. 25 (6): 1212-34.

________.
1971 "L'enquête Nationale Démographique Tunisienne." Population. 26 (Numéro Spécial) mars: 205-44.

Walle, Etienne van de.
1966 "Some Characteristic Features of Census Age Distributions in Illiterate Populations." American Journal of Sociology. 71 (5) March: 549-55.

________.
1968 "Characteristics of African Demographic Data." The Demography of Tropical Africa. Brass, William, et al. (eds.).: 12-87.

APPENDIX

Since the procedure used in making stable population estimates is slightly different from that proposed by Coale and Demeny (U.N., 1967: Population Study Number 42: 12-24, 61-68), the calculations used to derive estimates for Morocco Muslem females under Set 1 of age distribution adjustments and Hypothesis 2 of growth rate estimates (see Table 20) are given here as a detailed example. Anyone wanting to follow this discussion will have to have a basic acquaintance with the 871 pages of tables in Coale and Demeny (1966). Essentially, we want to interpolate among these calculated tables or models on the basis of the given growth rate and the given age distribution in order to identify the appropriate model.

Since the proportion at ages (0-9)/25+ is the age distribution measure that is to be used, this proportion in the given population must first be calculated. From Set 1 of age distribution adjustments (section 4.3) and the 1960 census results adjusted for migration (Table 3), we can calculate:

$$\frac{(0\text{-}9)}{25+} = \frac{1{,}971{,}513 + 77{,}500 - 25{,}000}{2{,}306{,}354} = \frac{2{,}024{,}013}{2{,}306{,}354} = .87758$$

Using the Coale-Demeny tables for the West family of female stable populations and for estimates through the growth rate (1966: 26-73), the next task is to calculate the proportion (0-9)/25+ in these models. These are calculated for growth rates 2.5 and 3.0, since these are the two rates, among the thirteen given, that encircle the rate of 2.8 (given rate). The Coale-Demeny tables give proportions in the various five-year age groups and cumulated proportions to various ages (see the

series of tables on the left-hand pages of Coale and Demeny, 1966). The proportion required can be calculated as:

$$\text{Proportion } \frac{(0\text{-}9)}{25+} = \frac{\text{proportion to age 10}}{100 - \text{proportion to age 25}}$$

e.g., for level 10 at growth rate 2.5, we have:

$$= \frac{31.68}{100 - 63.19} = .86064$$

The mortality levels used are chosen by trial and error in an attempt to approximate the proportion .87758, which is the given proportion (see Table 30, columns 2 and 3).

TABLE 30. CALCULATIONS OF STABLE POPULATION FOR MOROCCO MUSLEM FEMALES WITH GROWTH RATE OF 2.8

MORTALITY LEVEL (1)	PROPORTIONS (0-9)/25+		
	r = 2.5 (2)	r = 3.0 (3)	r = 2.8 (4)
1	1.41908		
2			
3			
4			
5	1.00052		
6			
7			
8	.93574		
9	.89614	1.07808	1.00530
10	.86064	1.02833	.96125
11	.82810	.99912	.93071
12	.79896	.96449	.89828
13	.78385	.93339	.87357
14	.74874	.90625	.84325
15	.72547	.87898	.81758
16			
17			
18			
19		.78769	
20	.63079	.76850	
21		.75031	
22		.73290	
23			
24	.57218		

Next the proportions for growth rate 2.8 are calculated by interpolation (Table 30, column 4) in the following way:

Proportion at growth rate 2.8 = (proportion at rate 2.5) x .4 + (proportion at rate 3.0) x .6

e.g., for level 10 we have:

.86064 x .4 + 1.02833 x .6 = .96125

It can now be seen from Table 30, column 4, that levels 12 and 13 encircle the given proportion of .87758. The exact level is calculated by interpolation:

$$\frac{\text{highest proportion - given proportion}}{\text{highest proportion - lower proportion}} = \frac{.89828 - .87758}{.89828 - .87357} = .8$$

Therefore the exact level is 12.8.

The various parameters of the identified model (r = 2.8, mortality level = 12.8) can now be obtained by interpolation from the parameters given at the bottom of the Coale-Demeny tables. In the case of the birth rate, for example, one must first interpolate between 2.5% and 3.0% growth for each of mortality levels 12 and 13:

Birth rate at growth 2.8 = (birth rate at growth 2.5) x .4 + (birth rate at growth 3.0) x .6

Level 12: 42.43 x .4 + 47.44 x .6 = 45.436

Level 13: 40.76 x .4 + 45.65 x .6 = 43.694

We can not interpolate between levels 12 and 13 to get level 12.8:

(birth rate at level 12) x .2 + (birth rate at level 13) x .8 =

45.436 x .2 + 43.694 x .8 = 44.04

The other parameters are calculated in exactly the same manner with a slight difference for the percentage of under-enumeration. For the latter, we first add the proportions at ages 10-14, 15-19, and 20-24 in the models, then interpolate for growth rate 2.8 and for mortality

level 12.8 Having obtained this proportion, which in this case is .3146133, we subtract it from 1.00 to get the proportion at ages other than 10-24. This proportion is divided into the population enumerated at ages other than 10-24 (after adjustments) to obtain the total population:

$$\text{Total population} = \frac{\text{given population at ages (0-9)} + 25+}{\text{proportion in model population at ages (0-9)} + 25+}$$

$$= \frac{2{,}024{,}013 + 2{,}306{,}354}{1.000 - .3146133} = \frac{4{,}330{,}367}{.6853867}$$

$$= 6{,}318{,}137$$

Subtracting the enumerated population from this new total population, we obtain the implied under-enumeration:

$$\text{Under-enumeration} = 6{,}318{,}137 - 5{,}523{,}285 = 749{,}852$$

$$\text{Percentage under-enumeration} = \frac{794{,}852}{6{,}318{,}137} = 12.6$$